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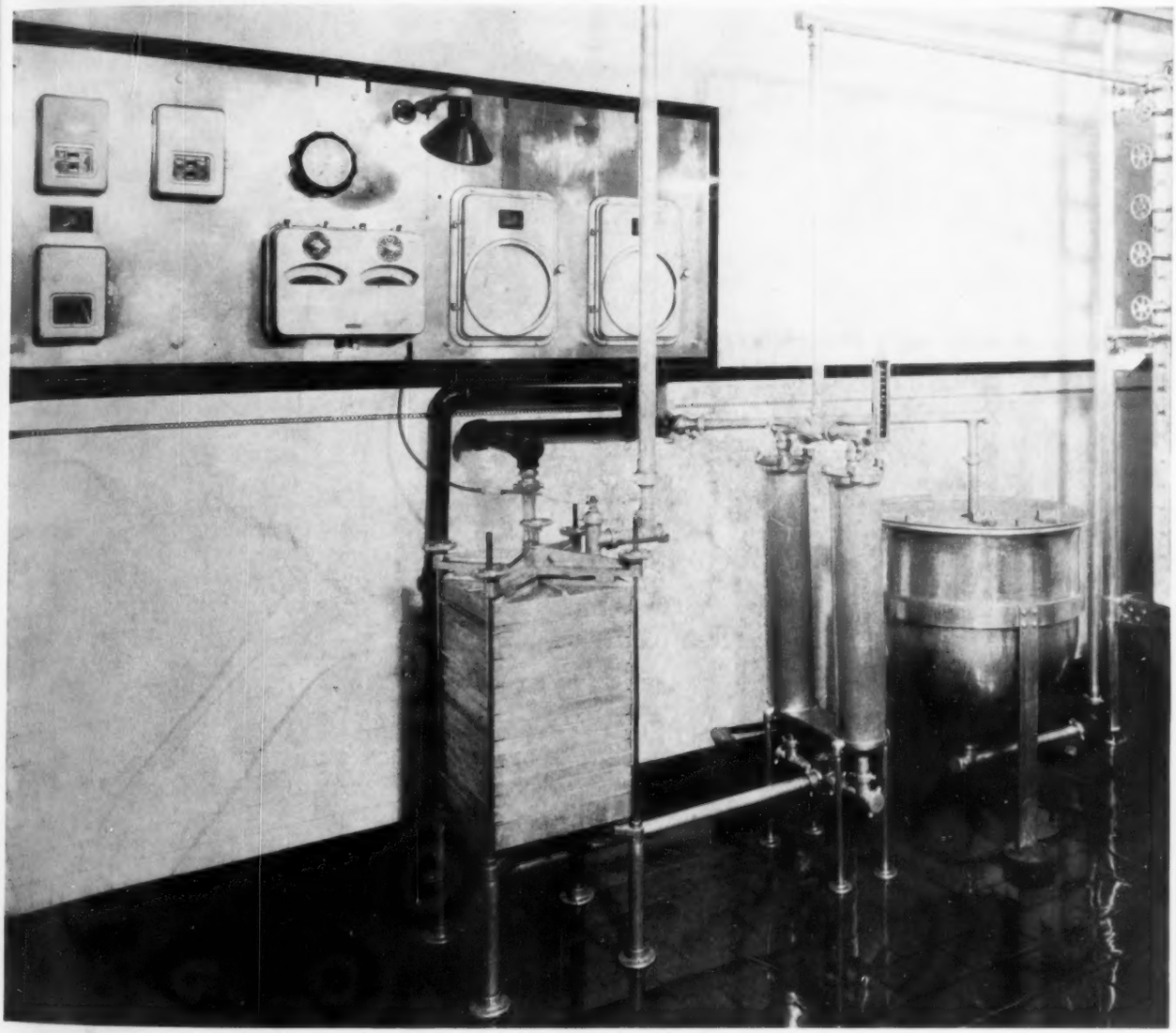
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 5 DECEMBER, 1932 NUMBER 12



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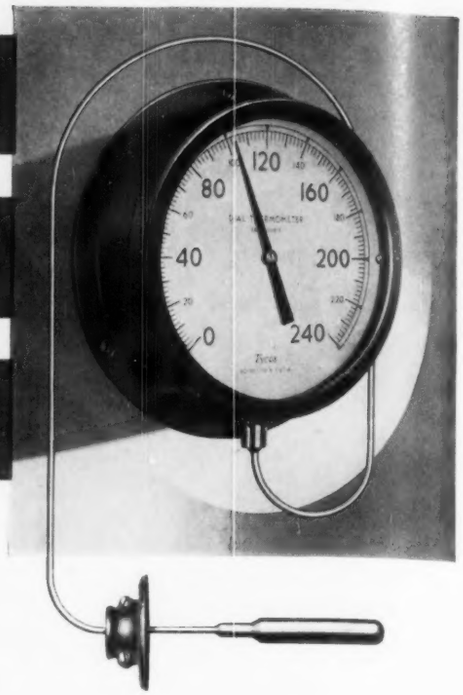

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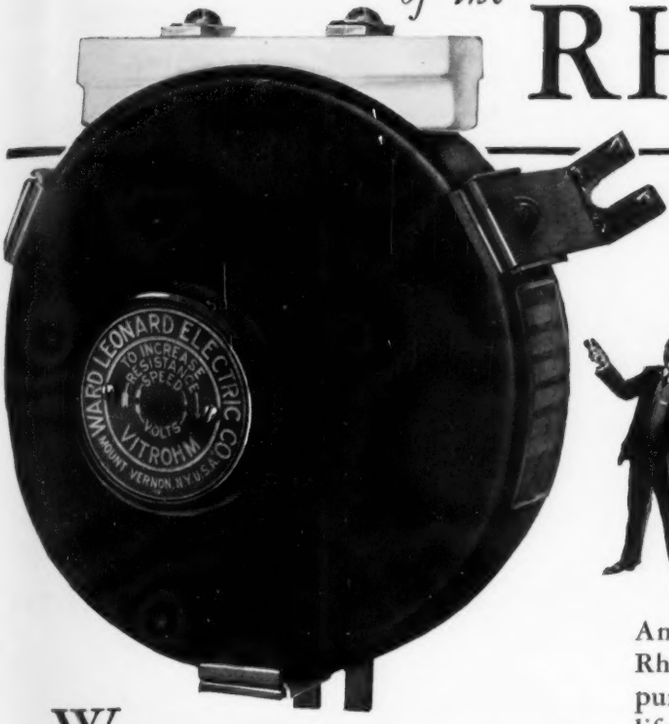

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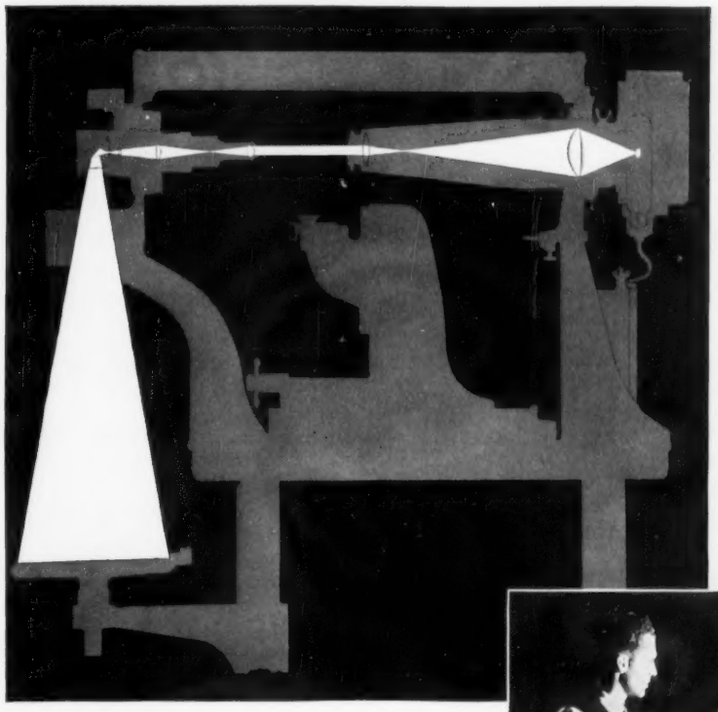

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Path of light through the contour projector; the part to be outlined is placed in the path of the parallel rays which are afterward diffused.

Below
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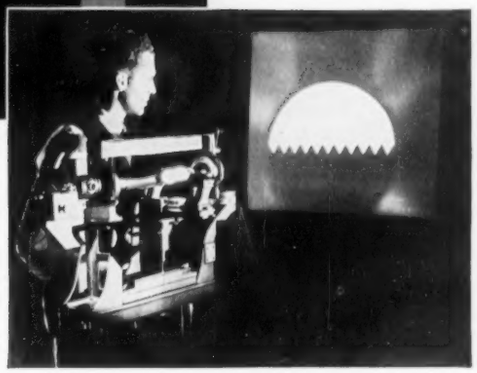

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EDITORIAL COMMENT

In This Issue

◆ If it were not for instruments, the tires you ride on—both tubes and casings—could not be processed as well as they are; they would cost more; they would wear out sooner. And now instruments are being used to bring tires still closer to perfection by making them less noisy—as explained by **W. F. Billingsley** in this month's first article.

◆ **Optical Indicators** are discussed with a profusion of illustrated details and sapient comments by **Prof. De Juhasz** in this month's installment of his valuable book on this class of instruments.

◆ Concluding his outspoken discussion of **Positive Fluid Meters, M. F. Béhar** goes on also to bring out—as never done hitherto in print—the advantages and limitations of various liquid meters.

◆ As a rule we do not pick out on this page any particular device described in the **New Instruments Department,** but as we write this we read in the papers that the photographic racing timer (page 289) has been adopted officially by the A. A. U. It is long since we wore spiked shoes but we nevertheless exclaim, "At last!"

◆ Readers who have not missed an issue in the five years since Vol. I, No. 1, probably know by heart that the other departments are **Abstracts, Book Reviews, Manufacturers' Literature,** and the handy **Instruments Index.** And last but not least, the **Advertisements** include announcements of "just what you need."

◆ ◆ ◆

The Front Cover

◆ Critics of the "machine age" ought to be forbidden to drink pasteurized milk if after visiting a modern "model dairy" they refuse to recognize the blessings of automatic temperature control. Not many miles from this office is a milk plant where aluminum is used profusely—which led the Alcoa people to take the photograph shown—but what interests our circle even more is the control of the Electropure Plate Heater to ± ¼° F. effected by the Bristol instruments and Sundh relays on the handsome panel.

Leadership

EVERY reader of this magazine pays the butcher, the baker and the instrument maker with money that comes directly or indirectly from industry—from the *profitable* conversion of raw materials and raw energy into *saleable* goods and services. In many cases, no doubt, the profits were made years ago and salaries are paid out of shrinking reserves. For industry is at a crucial turning point.

Some cells in living tissue die shortly after their formation; others thrive indefinitely. So in any industry do some plants starve to death while others grow on and on. Complex and multifarious as is a modern industry, its individual units are subject to the implacable law of existence which is feed or die. A starved organism cannot remain alive; a business that makes no profits cannot continue.

Some species of animals hibernate, but when they wake up they must feed—and in the vernal scramble, woe to the individuals that fail to go after food and eat their fill! The industrial world is emerging from a thirty-month winter of suspended animation. Woe henceforth to the businesses that fail to go after that vitally necessary food known as profits!

Organisms incapable of adapting themselves to changing biological conditions must perish; so must a business cease to exist which does not adapt itself to changing technological conditions.

An era of competition has begun. Its rigors will not be tempered; its fierceness can no longer be allayed, for American industries are not like a herd of bisons that can be saved from starvation by a benevolent government. Close your ears to wish-inspired rumors of paternalistic panaceas, for the socialistic Santa Claus is a myth. Open wide your eyes to the grim reality. *Adapt* your plant to rapidly changing conditions, so that your business may regain the ability to sustain its own existence by feeding itself—by making profits. In short, *modernize!*

Modernization is not only a way out: it is the way forward. In the pitiless race for profits those plants are doomed which lag behind; but fortunate are those that rid themselves in time of obsolete machines and outworn methods and arm themselves with perfected equipment and modern methods—for they will not only eat their fill from the start, but this hearty breakfast will make them abler yet to pursue subsequent meals.

Many and varied are the phases of the modernizing process, but it consists essentially of controlling all variables. Hence the importance of Instrumentation.

Perhaps the chief value of Instrumentation, at this critical time, is that it permits modernizing at minimum cost. Many a department which hasty judgment condemns to the scrap heap, because its equipment seems obsolete in comparison with the latest designs, can not only be saved but can be made profitable—even in the 1932-33 meaning of profitable—by the judicious installation of measuring and controlling instruments such as have recently been brought out. So take heart: leadership may be won by an effort well within your actual power!

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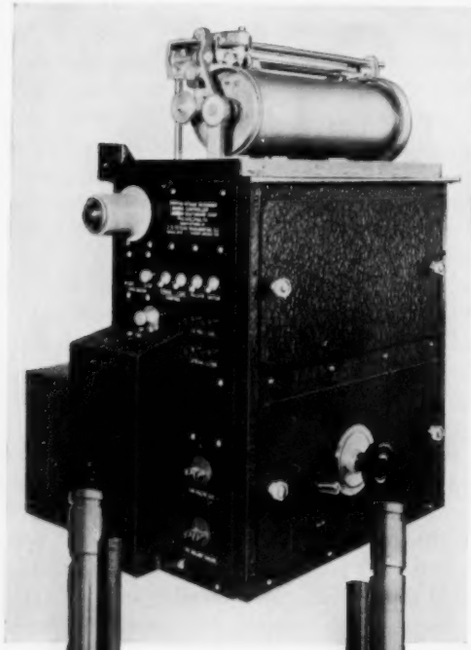
The Counter Reads 60

In calling attention to the fact that INSTRUMENTS now ends its fifth year, we make only two brief comments: (1) If it were not for the *growth* of interest in measurement and control, we could not have survived. (2) This growing interest indicates that although the financial structure of industry is still shaky, its foundations of enlightenment and of striving for progress remain as solid as ever.

This sixtieth consecutive monthly issue is the twelfth since we changed from pocket-size to the usual format of technical journals. We invite comments from both old and new readers. Are we giving you exactly what you want? What improvements (within reach, of course) would you suggest?

SOUTHWARK announces
THE RECORDER-CONTROLLER



In the National Bureau of Standards, Washington, D. C., and in the Laboratories of the Corning Glass Works, the first units of a new type of Southwark-Emery Testing Instrument have recently been installed.

These instruments, known as the Stress Strain Recorder-Controller, marks a long and important step forward in the field of materials testing. Used in conjunction with any testing machine having hydraulic load measuring means, it functions first as an autographic stress-strain recorder which produces an accurate graph of the stress strain curves of metals, wood, concrete, or other materials, and, second, as an instrument which, in addition, controls load application to effect constant rate of strain increment, constant rate of load increase and load maintenance at constant value.

Despite these more than human qualities, this instrument in no way limits manual control, and such control is inherent up to any predetermined point at which the instrument takes over the control function and proceeds to exercise it to a point elected by the operator.

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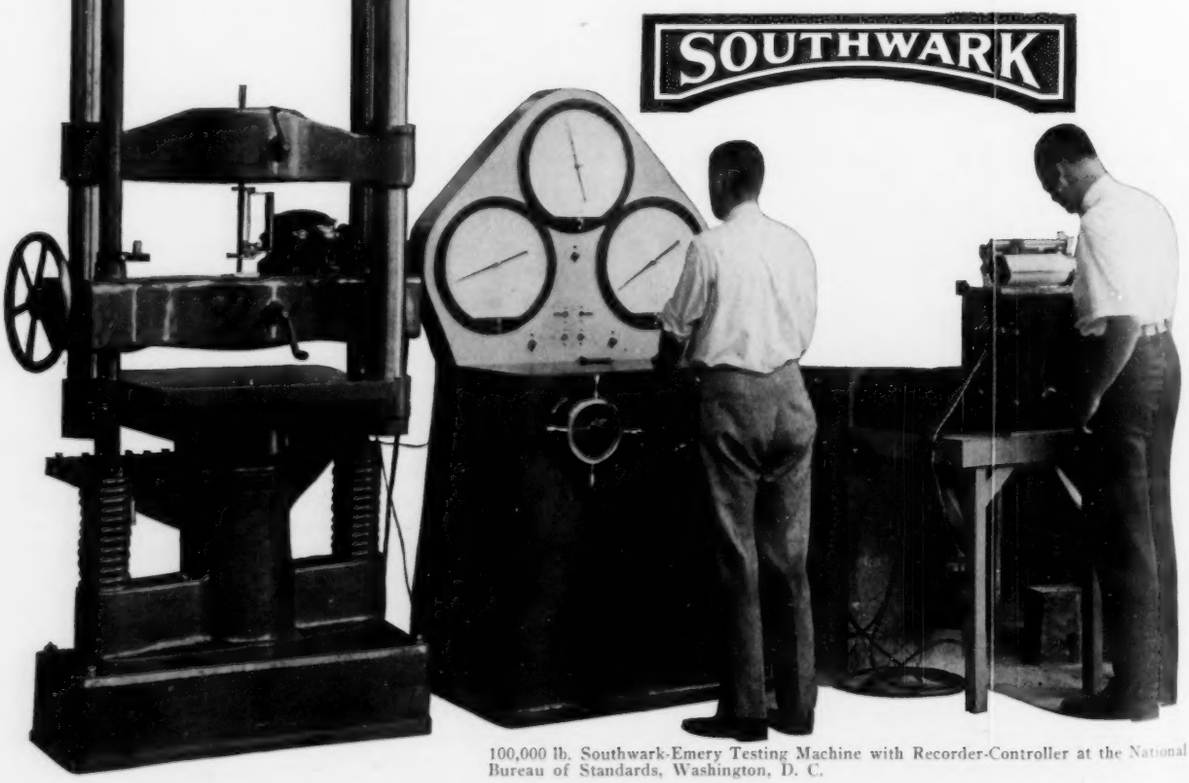


100,000 lb. Southwark-Emery Testing Machine with Recorder-Controller at the National Bureau of Standards, Washington, D. C.

Instruments Measure Effects of Tread Design and of Wear on Tire Noise

By W. F. BILLINGSLEY*

NOISINESS in tires has been attacked scientifically with a view to producing tires that will combine minimum noisiness with the fundamental requisites of safety and good traction. The B. F. Goodrich Co., of Akron, Ohio, started experiments on March 10 of this year and continued them through several months, to compare the noise produced by six types of tires run under exactly similar conditions. Tests were first made on new tires and then on the same tires after they had been run 1000, 2000 and 3000 miles.

The noises, it was found, came from three main causes, impact of the tire on the pavement, clatter of design on the pavement, and pavement roughness. It also was found that no tire is silent, not even the plain ribbed type. Application of any design other than straight circumferential ribs is done at the expense of quietness.

To make these tests as comprehensive as possible the most modern noise measuring equipment was obtained, installed in a Goodrich test car operated as nearly as possible under the same conditions at all times. Noise measuring equipment consisted of a Jenkins and Adair condenser microphone, a Burgess acoustimeter and a 1000-cycle low pass filter. The condenser microphone converted noise pressure variations into variable e.m.f's which the acoustimeter indicated in decibels. The filter, by shutting out shrill sounds, served to reduce wind noises without materially affecting tire noises.

Carried in an iron box, the microphone was padded with felt to shield it from car vibrations. The iron box was bolted to the car floor in the position normally occupied by the left end of the rear seat cushion. A 4½ in. fiber tube, fitted closely about the microphone diaphragm, extended flush through a hole in the car floor over the rear axle and 12 in. to the right of the left rear wheel. This hole in the car floor, therefore, was the location of the "electric ear." Acoustimeter and battery case rested on a rack on the right side of the car in the position normally occupied by the right end of the rear seat cushion.

Two men conducted each test. One drove the car and observed the speedometer, the other operated the acoustimeter and recorded its readings. Tests were made on a concrete roadway, in excellent condition, affording a stretch of about 1½ miles practically without grades or curves. All measurements of sound were on dry pavement. Every test was made with the car coasting in free wheeling, ignition turned off. All motor and ignition noises were thus practically eliminated.

The car was sped up to approximately 65 miles an hour, and then, with the engine turned off and in free wheeling, allowed to drift down to 10 miles an hour. Noise readings were made on the instant the car decelerated through speeds of 60, 50, 40, 35, 30, 25, 20, 15 and 10 miles an hour. Each test was repeated four times, the car twice traveling south and north so that effects of wind direction or road irregularities could be averaged.

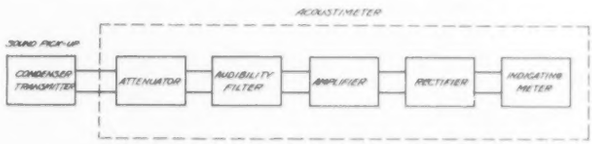


Fig. 1. Schematic diagram of the Burgess Acoustimeter used in the Goodrich tests. It consisted of an attenuator calibrated in decibels; a filter switch giving a selection of (1) flat frequency response (2 and 3) filters weighted in accordance with Fletcher's audibility curves at 30 db. and 60 db.; (4) an external plug for connecting to a frequency analyzer or special filters; an amplifier; a vacuum tube rectifier; an indicating meter calibrated in decibels. The acoustimeter contained all necessary A, B and C batteries, while a separate battery box supplied the transmitter amplifier tube and polarizing potential.

*Test Engineer, The B. F. Goodrich Rubber Co., Akron, O.

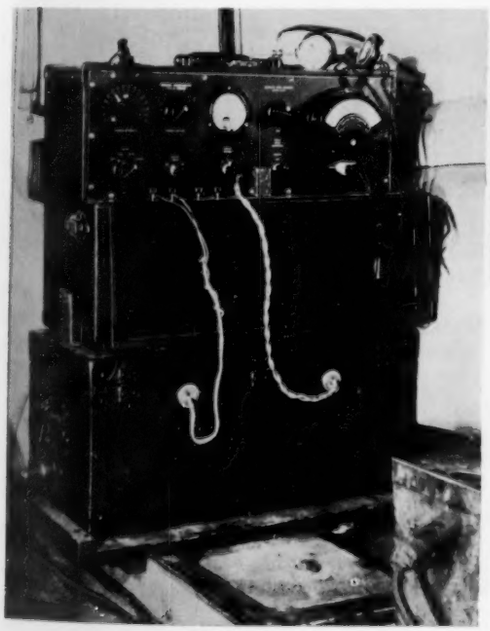


Fig. 3. Closeup of iron box, padded with felt, which contains the microphone.

Fig. 2. (at left) Closeup of instruments and instrument board.

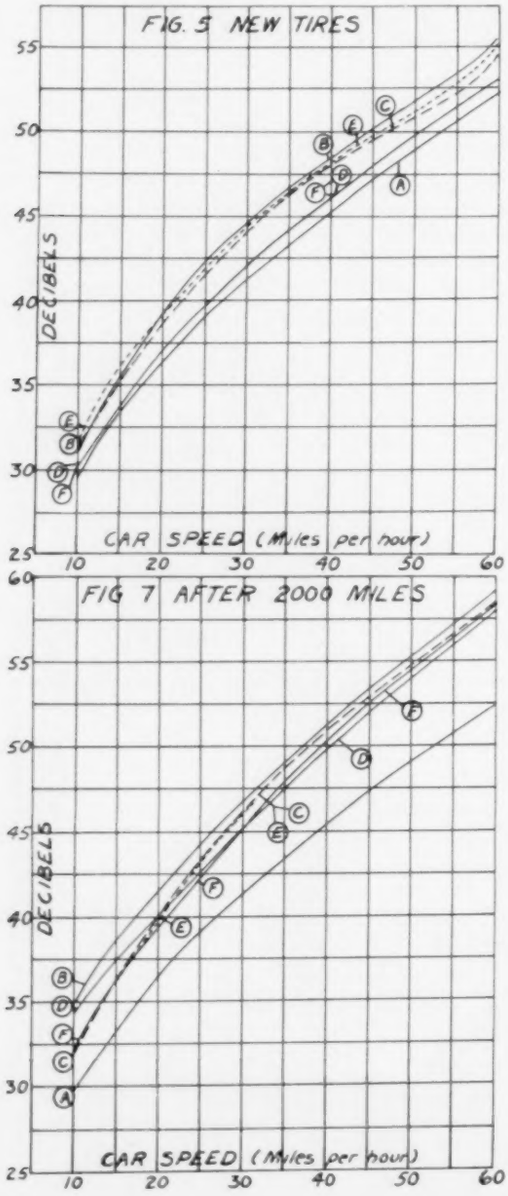
Fig. 4. B. F. Goodrich Company engineer operating noise measuring equipment in tests to determine noises created by various types of tires with a view toward designing tires that will create the least noise while still retaining maximum traction and safety.

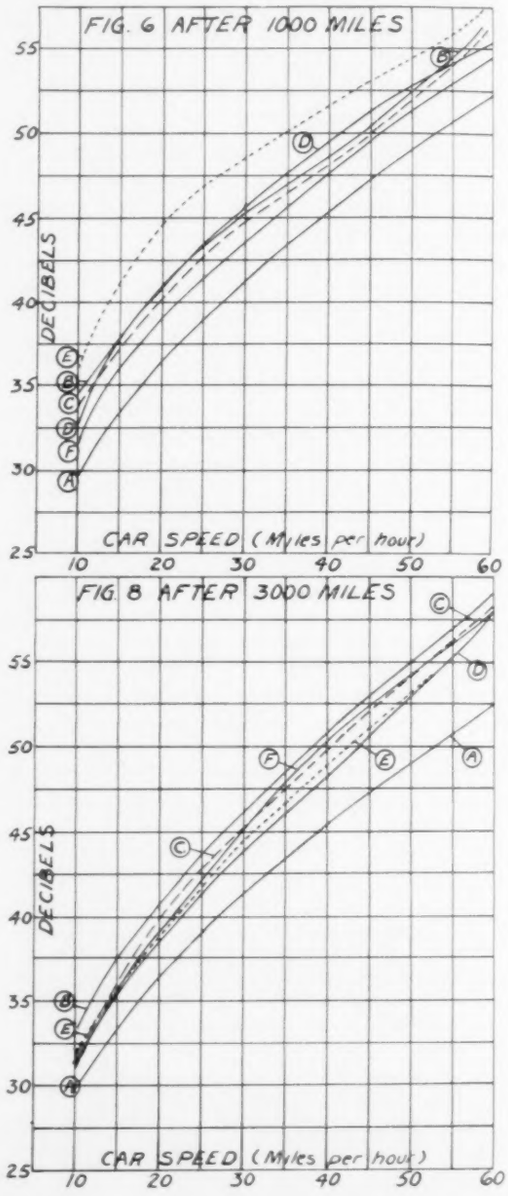
Care was taken that tires were always placed on the car in the same position as on previous runs so that any tendency to develop heel and toe wear or other irregularities was not affected by change in direction of rotation or by change from front to rear wheels. Tread design, depth and tread profile curvature were measured on the new tires and at the end of each 1000 miles. Tires tested were all 7.00/18 six-ply.

Noise measurements throughout were recorded in decibels. To correct for the threshold of hearing, add 44.5 decibels to each reading in Figs. 5 to 8, but for comparative purposes this is not necessary.

Fig. 5 shows noise measurements on new tires. The ribbed tread (Set A) was introduced into these tests as an indication of the minimum in operating noise possible under the existing conditions of tire size, load, and inflation pressure. The tires take three groups in Fig. 5. The ribbed tire is quietest, next comes Set F and Set D with only straight ribs in the center of the tread. In the noisiest group are Sets B, C and E. On the new tires, those with the most broken up designs make the most noise. However, it is indicated that staggering the designs, or making them of unequal size, makes for quietness when the tire is new.

Fig. 6 shows that all the tires have become considerably noisier after being run 1000 miles. This is particularly true of Set E and is due to very bad heel and toe wear, producing more design clatter. Set D also shows more rapid increase than others, due to irregular wear on shoulder design. Sets B, C and F show about the same rate of increase.





It will be seen in Fig. 7 that at 2000 miles the tire noises have again changed in relation to one another. Sets B, C and F continue to increase, but the rate of rise is greater on Set F than on the other two. Noise of Set E has decreased from that at 1000 miles, due to rapid tread wear on center designs and resultant decrease in heel and toe wear. Set D noise has increased but slightly over that at 1000 miles, due to smoothing up of slight heel and toe wear present at 1000 miles.

All noise readings at 3000 miles are less than at 2000 miles, Fig. 8 shows. This is due to tread wear counteracting the effect of heel and toe wear and flattened tread profiles.

The ENGINE INDICATOR

Its Design and Theory

By KALMAN J. DeJUHASZ*

(Continued from November Issue)

OPTICAL INDICATORS

In the optical indicators the minute motion of the measuring parts is magnified by means of a mirror and a reflected ray of light, and is recorded by photographical means.[1]

A representative of this class is the Hopkinson indicator (Fig. 76) in which a piston loaded by a beam spring is used. The piston displacement produces a rocking motion of a mirror around an axis perpendicular to the cylinder axis while the whole piston, spring and mirror assembly is given another rocking motion, proportional to the volume change, around the cylinder axis. The combined motion of the light ray is photographed by means not shown on the illustration.

In the so-called "Manograph" of Hospitalier and Carpentier (Fig. 77) a diaphragm is used as a pressure measuring element. The circular mirror is held by small springs against three support points forming a right isoceles triangle. The rectangular apex is stationary; the second point is moved by the diaphragm in proportion to the pressure; the third point in proportion to the piston stroke (by means of a small crank-connecting rod mechanism driven from the engine). Thus the mirror executes the necessary compound motion.

The optical indicator of the Société Genevoise d'Instruments de Physique (Geneva, Switzerland) (Fig. 78) is a more recent design based on the diaphragm principle and is of sturdy construction.

The spring constant of a steel diaphragm varies with the temperature, its scale therefore is affected by the heat of the cylinder gases. In order to eliminate this error source, in the optical indicator of O. Schultze, a very weak diaphragm is used and a separate cantilever spring provides the necessary elastic force (Fig. 79).

*Asst. Professor of Engineering Research, Pennsylvania State College.

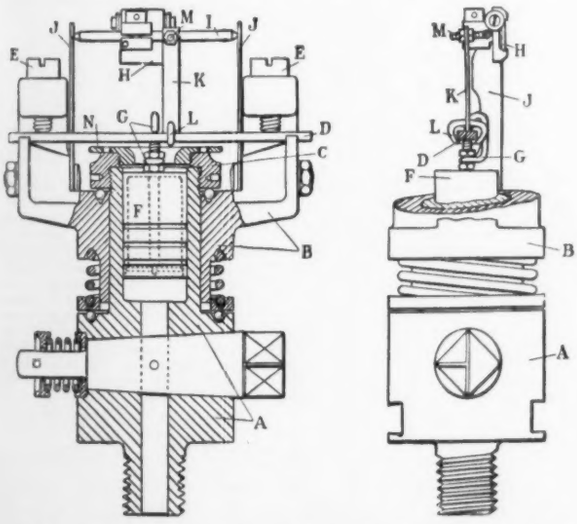


Fig. 76. Hopkinson's Optical Indicator (Dobbie McInnes and Clyde, Ltd.) The piston F presses upon bar spring D clamped at both ends. The motion is transferred to the mirror H by means of rod K and lever M. A second motion, proportional to the motion of the engine piston, is imparted to the frame B, in which the mirror H is pivoted, around the piston axis. Hence the ray of light reflected from the mirror describes the diagram. The rest of the optical arrangement (lamp, photographic plate) is not shown on the drawing. Note ball bearings provided for the rocking frame. Method of clamping imparts to the bar spring an initial bending which eliminates backlash.

The optical indicator designed by Prof. Burstall[2] (Fig. 80) is characterized by sturdy design, great attention to detail and a thoroughgoing division of functions among the various elements. A piston loaded by a cantilever spring is used. The light ray is deflected, in succession, by two mirrors, having their axes of rotation perpendicular to each other. One of them is fastened to an extension of the spring and its angular displacement is proportional to the pressure. The angular displacement of the other mirror, which is produced by a positive drive from the engine, is proportional to the displacement of the engine piston. Other points worthy of note are: straight-through connection to the indicator piston without any restriction of passage; pressure lubrication for the piston; water cooling for the indicator cylinder and also for the cock valve; a cock valve of hardened steel which is not likely to seize; use of ball bearings for the rocking shaft driven from the engine; use of a high candle power, metal filament lamp, mounted into an adjustable bracket; restriction of the light ray to the dimension of about 0.002 in.[2] by means of two narrow, adjustable slits perpendicular to each other. The housing is an aluminum casting. The compartment for the photographic part is separated from the indicator part by means of a glass plate, in order to protect the photographic plate from the oil fumes. The natural period of vibration is stated to be 1/1200—1/1700 sec., according to the stiffness of the spring used.

In the Midgley indicator (Fig. 81)[3] the piston is placed deep into the cylinder, flush with the cylinder wall, in order to avoid an enlargement of the engine cylinder space and the uncertain influence of the connecting tube. The pressures are recorded on a crank angle (or time) basis by means of a rotating polygonal mirror.

In an optical indicator recently developed by F. Nakanishi[4] (Fig. 82) the indicator errors arising from the vibration of the engine are greatly reduced. The engine pressure acts upon the piston a which is loaded by the beam spring b. The bending of the beam imparts to the two mirrors c_1 and c_2 a symmetrical angular displacement in proportion to the magnitude of the bending force. The optical arrangement is shown in Fig. 82a. The pencil of light passing through the slot d is collected and reflected in turn by a large lens and both mirrors c_1 and c_2 and falls upon the revolving mirror e. The two mirrors compensate for any angular vibration of the instrument and obtains a motion proportional to the engine piston stroke by means of suitable levers shown on the drawing. The phase can be adjusted by means of an epicyclic gearing and handwheel f. The mirror is kept in contact with the three points by means of springs. Fig. 77a is the general arrangement of the instrument showing light source, prism d and photographic plate a.

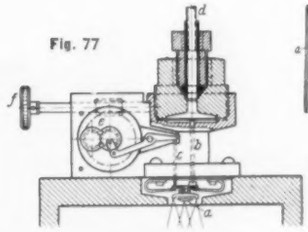


Fig. 77. "Manograph" of Hospitalier and Carpentier. Mirror a is supported on three points forming a right angled triangle. One point, in the center, is stationary. To the second point a motion is imparted, by the diaphram, proportional to the pressure through rod b. The third point at the end of rod c ob-

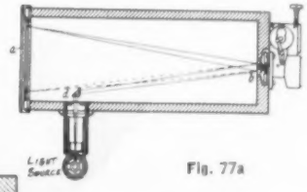


Fig. 77a

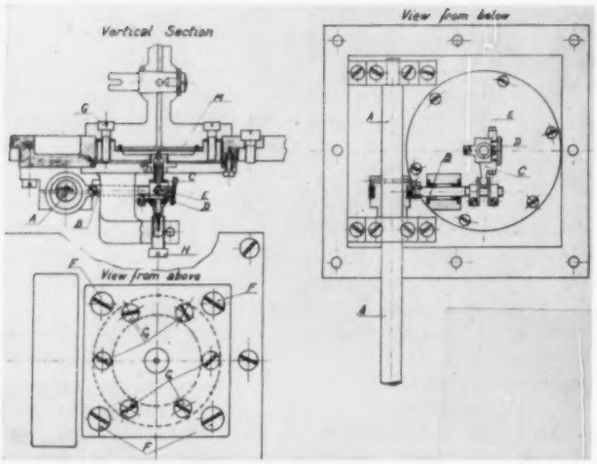


Fig. 78. Optical Indicator of the Societe Genevoise, Geneva, Switzerland. The pressure-proportional displacements of the diaphram M and the stroke-proportional displacements of the rod B are communicated to the mirror D in the manner shown in the drawing. Shaft A is driven from the engine at crankshaft speed. Note clamping of diaphragm M by means of ring with diamond shaped cross section.

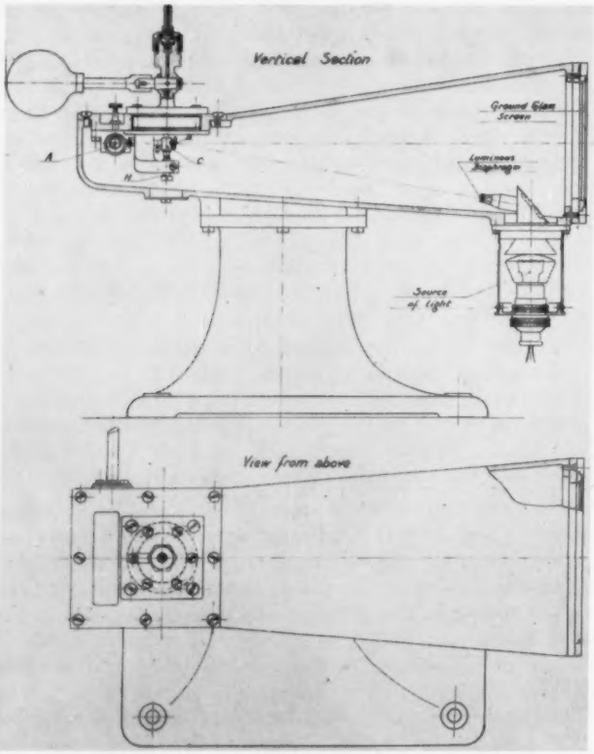


Fig. 78a shows the source of light, luminous diaphragm and ground glass screen.

dicator as a whole. Therefore this arrangement permits very large distances (actually 6 to 12 ft.) to be used between the mirrors c_1, c_2 on the one hand, and the light source and the revolving mirror on the other hand. Hence the magnification is exceptionally great, which permits the use of exceedingly stiff springs. The natural frequency of vibration of the mechanical system is stated to attain 5000 to 10,000 sec.$^{-1}$ with the spring stiffness of the order 1/1000 in. = 360 lbs./in.^{2}

In the "Proefstation Delft" of the Royal Dutch Shell Co. a very accurate optical indicator has been developed by W. J. D. van Dijck and J. J. Broeze and used in an investigation of the ignition quality of fuels.[5] It represents a distinct advance on existing types, incorporating numerous ingenious features which merit a detailed description.

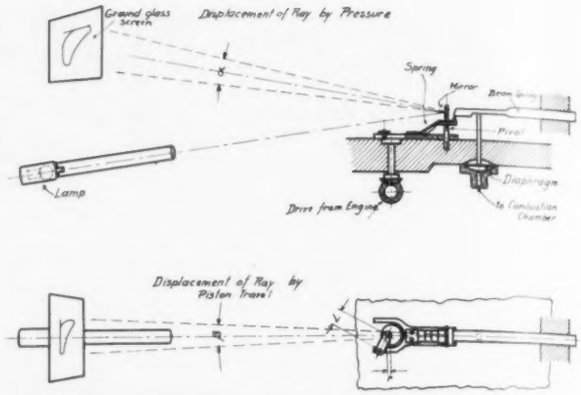


Fig. 79. OTA Manograph (OTA Apparate G.m.b.H. Frankfurt am Main, Germany). A weak diaphragm is used, the pressure force being counterbalanced by the force of a beam spring, which imparts its deflection to the mirror. This latter receives also a travel-proportional displacement from a small crank-connecting rod mechanism actuated by the engine through a bevel gearing.

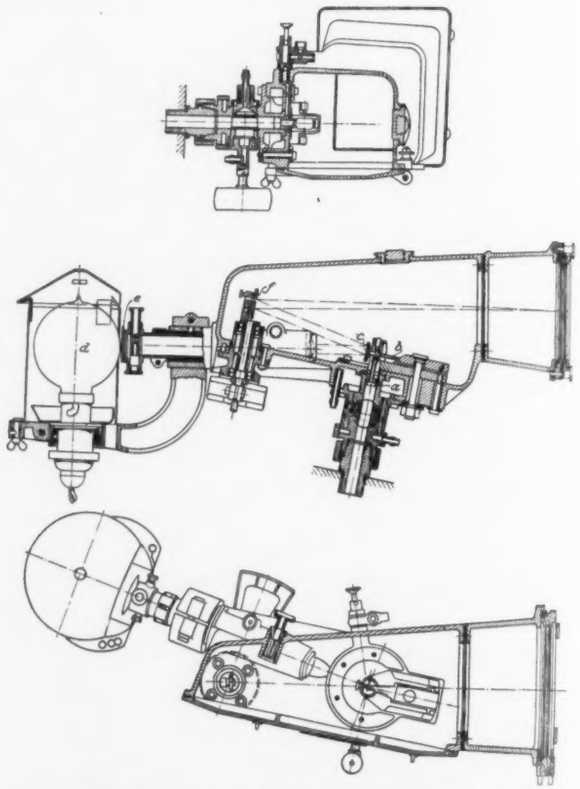


Fig. 80. Burstall's optical indicator. The piston a is connected to the beam spring b into the extension of which latter the mirror c is secured. The angular deflections of this mirror are proportional to the pressure. From this mirror the light ray is reflected onto another mirror f secured to a rocking shaft, mounted in ball bearings, actuated from the engine by means of a steel ribbon. The light of a "Pointolite" lamp passes through a square opening formed by two pairs of edges perpendicular to each other. The width of both slits can be closely adjusted. (Such an opening can be easily cleaned while a round hole is easily damaged if cleaned by a pin.) The photographic plate is protected from oil fumes by means of a glass plate separating the photographic compartment from the indicator compartment. Design points to note: Piston is barrel shaped in order to accommodate the curvilinear motion of the piston rod end which is fixed to the beam spring. The piston can be lubricated by means of a pressure oiler. Passage from the engine is 3/8 in. dia. Water cooling is provided for the indicator cylinder and the cock valve.

Fig. 83 shows the complete apparatus mounted upon an engine. The indicator consists of the pressure element, the pressure recording optical system, the travel-recording optical system, a lamp and case holding the photographic plate. The major elements are grouped around a sturdy central block firmly secured to the engine as shown in greater detail on Fig. 83a. (This latter figure represents a more recent modification of the original form shown on Fig. 83.)

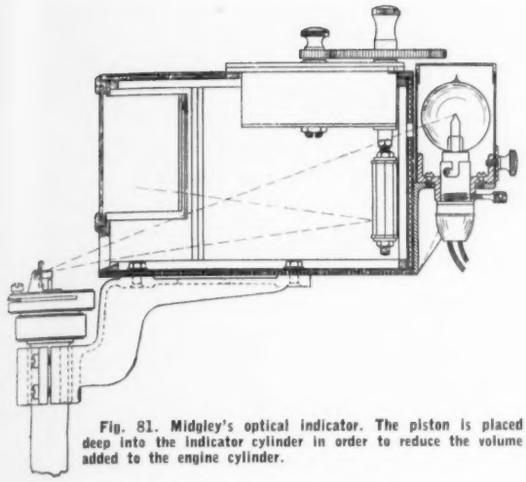


Fig. 81. Midgley's optical indicator. The piston is placed deep into the indicator cylinder in order to reduce the volume added to the engine cylinder.

Fig. 81a

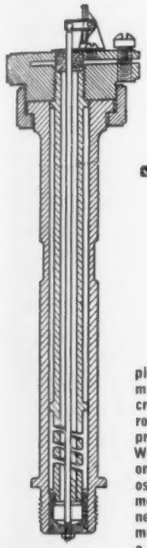


Fig. 81b

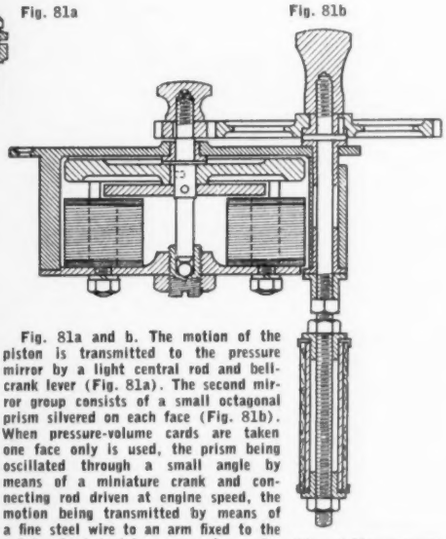


Fig. 81a and b. The motion of the piston is transmitted to the pressure mirror by a light central rod and bell-crank lever (Fig. 81a). The second mirror group consists of a small octagonal prism silvered on each face (Fig. 81b). When pressure-volume cards are taken one face only is used, the prism being oscillated through a small angle by means of a miniature crank and connecting rod driven at engine speed, the motion being transmitted by means of a fine steel wire to an arm fixed to the mirror shaft, the wire being kept taut by means of a spring. When taking pressure-time cards the octagonal mirror is given a rotary motion, being driven by a small electric motor (Fig. 81b) synchronised with the engine by means of a distributor driven at engine speed.

The pressure element (Figs. 83a and 83b) is a hardened steel disk clamped between two steel blocks. The first block B contains the pressure chamber and its connections to the engine cylinder. It is ground into a valve housing mounted directly on the cylinder head and contains a shut-off valve H and a ventilation valve J. The latter can be also used to give connection to a compressed

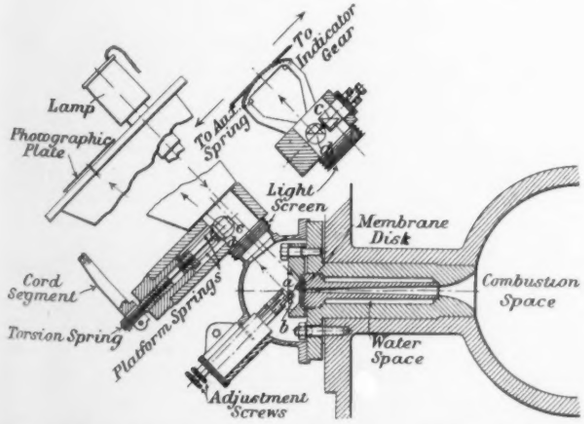
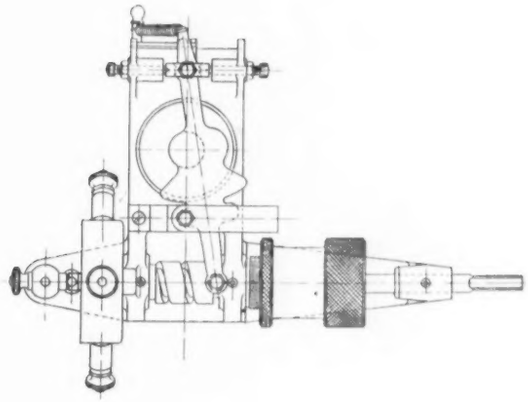


Fig. 83. Optical indicator of the Proefstation "Delft" devised by van Dijck and Broeze. General arrangement of mounting on an oil injection engine.



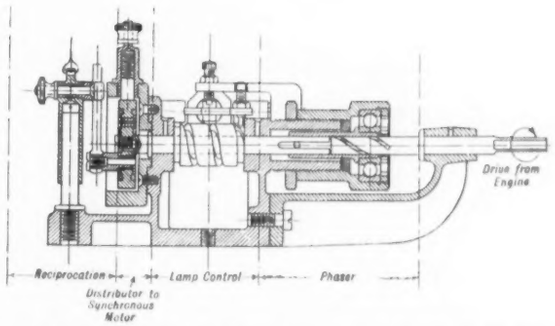


Fig. 81c shows the pressure-time synchronizer. Here is seen on the left the reciprocator which actuates the octagonal mirror, next to it the distributor with 3 contacts, which controls the speed of the synchronous motor, and finally a worm which moves a swinging arm by the depression of which contact is made so that the lamp illuminates the photographic plate for a single cycle only. The circle seen in the plan view is an electro-magnet which pulls the swinging arm down until it engages with the worm. The worm has two turns so that the stroke of the arm is completed in two revolutions or one cycle of the engine. (See The Engineer, March 2, 1928.)

Fig. 82a

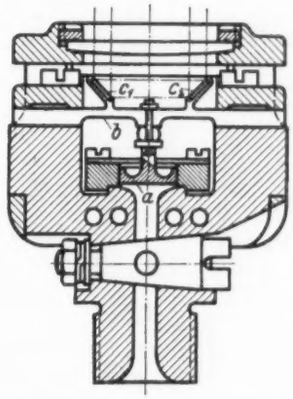


Fig. 82a and b. The optical indicator of Nakanishi. The characteristic feature of this indicator is the employment of two mirrors fastened symmetrically upon a beam spring which is connected to the indicator piston. Owing to this arrangement the effect of engine vibrations upon the light ray is compensated which renders possible an unusually great magnification. a is the indicator piston, b is the beam spring, c_1 and c_2 are the mirrors; d is the light slit; e is the recording drum upon which the photographic film is fixed. The holes in the body serve for water cooling.

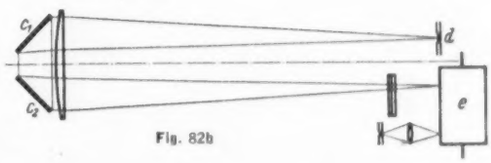


Fig. 82b

air supply with which the indicator can be calibrated. In case of necessity the valves can be dispensed with as the diaphragm is very durable. The free diameter of the diaphragm is 30 mm. for low speed engines, and 28 mm. for high speed engines where higher pressures occur and therefore greater stiffness is needed. The chamber is only 0.1 mm. deep. The connection to the cylinder is tapered from 5 mm. at the cylinder to 1.5 mm. at the indicator, in order to keep the volume small and to eliminate the errors arising from surging. The total air volume is about 700 mm.^{3}, of which 60 is in the pressure

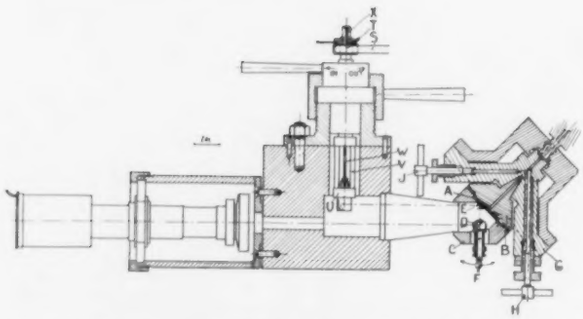


Fig. 83a. Optical indicator of the Proefstation "Delft." G valve housing for shut-off valve H and ventilation valve J. The diaphragm A is clamped between steel blocks B and C. The light from the lamp Y falls upon the reflecting prism D, hence to diaphragm-prism E, then to prism U to which a motion proportional to that of the engine piston is imparted by steel band S, drum T and shaft X.

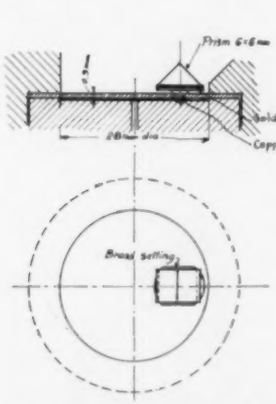


Fig. 83b. Optical indicator of the Proefstation "Delft." Details of the Diaphragm and Prism.

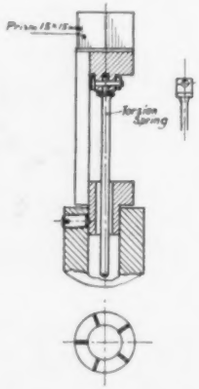


Fig. 83c. Optical indicator of the Proefstation "Delft." Details of Oscillating prism movement.

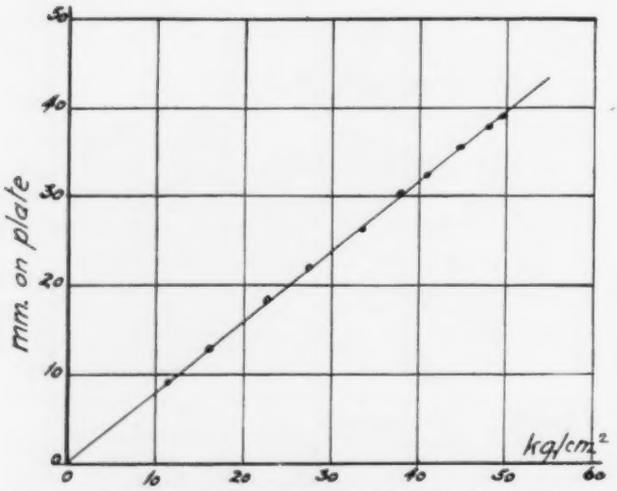


Fig. 83d. Calibration chart of the Proefstation "Delft" optical indicator.

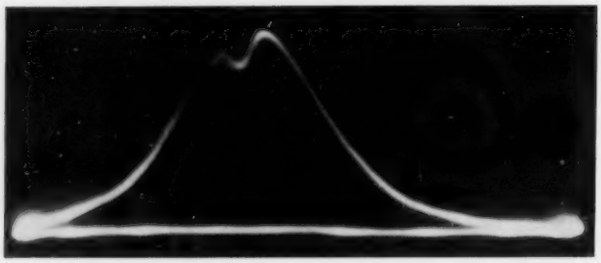


Fig. 83e. Offset indicator card taken with the Proefstation "Delft" optical indicator.

chamber. By using smaller connecting tube the total volume can be reduced to 300 mm.[3]

The second block C bears the reflecting prism D which together with the prism E mounted on the steel disk causes double reflection of the light beam.

The reflecting prism D on which a condenser lens is fitted with Canada balm is mounted in an adjustable bearer F which is clamped with some tension between two 1/8" balls. This allows an easy adjustment and, furthermore, permits the double functioning of the indicator. When the pressure valve H is shut off, so that the steel disk remains stationary, the holder of the reflecting prism can be connected to some part the motion of which is to be investigated (e.g. the fuel injection valve). In this manner on the same photographic plate the fuel valve diagram can be drawn as well as the pressure diagram.

The steel disk (Fig. 83b) is of hardened steel with the following properties:

Tensile strength: 80–90 kg./mm.² (110,000–130,000 lbs./in.²)
Elongation (L = 10 d) : 12 to 8%

and has a diameter of 38 mm. (1.5 in.) and thickness 0.9 mm. (0.035 in.). It is ground to a tight fit on the two blocks.

A prism, having 6 mm. (0.235 in.) rectangular sides, is mounted 8.5 mm. (0.31 in.) from the center of the disk. A hole of 1.5 mm. is drilled into the diaphragm into which the corresponding boss of a small platform is inserted and copper brazed. This may be done without distortion of the disk. The prism is clamped in a brass frame of 0.2 mm. (0.008 in.) thickness in such a way that the frame does not touch the lower, reflecting, side of the prism. The prism frame is then soldered to the platform. This method eliminates all the accessory mechanisms together with their sources of backlash, which are used in other optical indicators for pivoting the mirror and for transmitting the diaphragm motion to it.

The piston travel motion is provided by an eccentric of small dimensions, mounted on the crankshaft or on the camshaft as the case may be. The eccentric movement is transmitted to a roller and lever, which, by means of a steel ribbon S actuates a small drum T (Fig. 83c).

The oscillating movement of this drum is transmitted to a prism mounted on a platform and it is at the same time transformed into a much smaller angle by means of the elastic torsion between two springs. The angle necessary for obtaining a diagram of 10 cm. length at 60 cm. distance is 4° 30′ which would necessitate a lever of 127 mm. in conjunction with an eccentricity of 5 mm. Such an eccentricity already represents a limit as slight irregularities influence the movement of such short strokes. In order to overcome this difficulty the platform U with the prism is mounted on five radially mounted leaf springs V (40 mm. long, 5 mm. wide and 0.8 mm. thick) which are securely clamped into radial slots in two end rings (9 mm. high and 22 mm. dia.) (Fig. 83c). This assembly is susceptible to torsional deformation, but it is stiff against bending forces. The movement of the ribbon drum is transmitted to the platform by means of a torsion spring W (2.2 mm. dia., 140 mm. long between flat heads). The drum (24 mm. dia.) is mounted on a short shaft X running in two self-aligning ball bearings. The ribbon travel of 10 mm. (0.4 in.) would correspond to approx. 48° angular movement of the drum which is reduced by the elastic torsion to about 4° 30′ oscillation of the platform. This arrangement, though costly to

(Continued on Page A9)

Flow Measurement and Control*

By M. F. BEHAR†

CHAPTER XXIII
POSITIVE METERS
(Continued)

3. Classifications of Positive Meters

From a standpoint that does not require starting with a classification of the metered fluids, positive meters are logically divided into weighing and volumetric classes, and these into two and six types respectively, as was shown in Table XXII-1. Both in theory and practice, however, there are great differences between measuring liquids and measuring gases. The devices considered below, while they are all positive meters, and although they all register quantity, fall into two categories that have little else in common. In the first place, positive meters for liquids include weighers and tank and drum volumeters that fill by gravity and therefore cannot measure gases. Thus we may have "open" meters for liquids but only "closed" meters for gases. In the second place—and this is more important—there is not any commercially produced gas meter that will satisfactorily measure any liquid, nor can any closed positive volumeter for liquids be used quite satisfactorily for any gas whatever.

Specialization of positive meters has been carried far, as for example hot and cold water meters of one make, similar outwardly but differing not only in materials (certain molded products cannot be used for both cold and hot water) but in details of design. Specialization has given rise to new types and variants. Most of these modern meters register with smaller errors at all rates of flow than did their precursors—particularly at low rates—by virtue of generally improved design and construction; but many new forms give better results in service *because* of this very specialization—which in some cases implies also that for different applications they may be less suitable than older meters.

Logical consequences of the availability of more accurate meters for various particular fluids are (1) the revision of standard specifications and (2) the appearance of specifications where there were not any.

Natural consequences of the widespread adoption of rigid specifications for the metering of any fluid are (1) standardization of the meters made by different manufacturers—especially when dimensions and types are specified irrevocably—and (2) discouragement of "revolutionary" improvements. This is especially true when specifications permit 10% error at a stated "minimum test flow" which is more than 1% of rated capacity, and greater errors at smaller flows. Excellent work is nevertheless being done by bodies that have laid down standard specifications for domestic meters. In this connection it is well to mention (1) that some manufacturers of nutating-disk cold water meters make various "grades"—some registering 95% or more of the actual flow, instead of the specified 90%, when tested at "minimum test flow," and otherwise being suitable for industrial service; (2) that two or three makers of diaphragm gas meters, in like manner, can supply industrial users not only with special high-pressure meters but also with high-grade domestic models that prove satisfactory for many engineering applications.

An important consideration is that the physical standards of liquid measurement and of gas measurement differ widely from each other, whereas *within* each of these two fields the standards of measurement and the calibration methods are fundamentally similar. On the whole it seems not only logical but necessary to treat liquid and gas meters separately.

In the last decade the growth of the petroleum, automotive, aviation and oil-burner industries has fostered prolific development of specialized liquid volumeters. This process is still going on. At this writing, we learn, for

*Part Six of *The Manual of Instrumentation*.
†Engineering Editor.

PRESSURE INDICATORS

Extremely accurate gages embodying the dead weight gage tester principle are available in several sizes up to 36 inches in diameter for indicating at remote points the pressure of steam, water, gas, etc. These gages can be used with any pressure and are particularly suitable for magnified ranges. Ask for bulletin No. 110.

BOILER METERS

For generating steam at the lowest cost, the Bailey Boiler Meter is an important accessory on any boiler of 100 h. p. or larger. This meter records and totalizes Steam Flow from the boiler, records Air Flow supplied for combustion, and records Flue Gas Temperature. The operator is furnished, therefore, with the information essential to obtaining smooth, economical performance of the boiler. Write for Bulletin No. 44 describing how Bailey Boiler Meters can cut your expenses.

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Bailey Fluid Meters are the best solution to the problem of metering steam, gas, water and other liquids. Simple, rugged and extremely accurate, they can be depended upon to give long, trouble-free service. Bulletin No. 300 describes their many outstanding features. Write for a copy.

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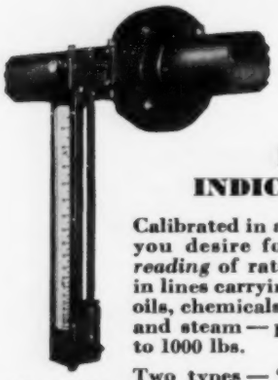

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TABLE XXIII-1

Positive Liquid Meters

"GRAVITATIONAL"

- Weighers
  - Single Tank
  - Double Tank
  - Multiple Tank
  - → Open
  - → Pressure or Vacuum
- Volumeters
  - Tank
    - Single Tank
    - Duplex Tilting Tank
    - Twin Tank
    - Multiple Tank
    - → Open
    - → Pressure or Vacuum
  - Multiple-Compartment Rotary Drum
    - → Open
    - → Pressure or Vacuum

"DISPLACEMENT"

- Volumeters
  - Reciprocating Piston
    - Crankless
    - With Conventional Crank
    - Nutating Plate
  - Oscillating Piston
  - Rotary Piston
  - Nutating Disk

Positive Gas Meters

- Dry
  - Rotary
  - Bellows
- Wet
  - Drum
  - Nutating Bell

example, that governmental curtailment of oil field production in several states, and proration, have created a demand for volumeters capable without frequent cleaning of measuring sand-laden crude oils, and also that gasoline meter specifications being proposed are so rigorous that nutating-disk meters, with or without adjustable by-passes, would no longer be called "positive" or "positive displacement" meters.

This large-scale metering of costly liquids and this rapid development of liquid volumeters are focusing attention on the characteristics of various new sub-types. For example, the various gasoline volumeters lumped under the head of "Type 1.2—Piston" comprise today several distinct sub-types.

There also have been developments in meters other than the piston meters, but not so "revolutionary" and therefore having less bearing on a scheme of classification designed for the practical man.

Table XXIII-1 represents the order in which the various types of positive meters are discussed below.*

The Piston and Disk Controversy

More than 95% of liquid volumeters in industrial service belong to the piston and disk types—thus named ten years ago, but never defined, by the A.S.M.E. Three factors make it imperative to insert here a seemingly over-lengthy discussion of these meters, supplementing the remarks in §1. These factors are: (1) the amazingly rapid spread of liquid volumeters throughout industry, (2) the bewildering babel of sales arguments put forth by some aggressive manufacturers and agents, and (3) the astonishing reluctance of impartial technical writers to dig out and publish the pertinent facts.

First, here are the two sides:

(1)

Extract from a private communication, dated November 28, 1932, to the author from a prominent manufacturer of NUTATING-DISK meters. (This firm manufactures no other type of liquid volumeter.)

"The A.S.M.E. report . . . contains one error. . . . In the six types of positive volumetric meters . . . the disk type is given as distinct from the piston type. . . . The disk type is one of the three piston types and the word disk is only an abbreviated term for nutating piston. The other two piston types are the oscillating piston and the reciprocating piston."

(2)

Extract from paper read before the A.S.M.E. Fluid Meter Committee at Bureau of Standards, Washington, Sept. 20, 1932, by Lyon McCandless, Pres., The Micro Meter Corp'n (makers of PISTON meters exclusively).

*The author does not presume to offer it as an "improvement" on the A.S.M.E.'s official classification, and only lays stress on one point: the division into liquid and gas meters.

". . . Demand for greater accuracy . . . a number of new positive displacement piston type meters which came to be known to the oil industry as the Positive-Displacement type in contrast to the 'Disk' type water meters. . . . It soon appeared that the 'disk' or displacing element of the 'disk' type meter was really a piston and, accordingly, was advertised as such . . . exceedingly confusing to the meter user. . . .

". . . There is a wide difference in the cost and performance of the two main types. . . . One type makes use of a flexible expanding sealing element that at all times maintains contact with the walls of the chamber in which the displacing element operates, and so prevents leakage. This type is, definitely, a true positive displacement meter. The other type has no flexible sealing medium but depends on working clearances to reduce the leakage to a minimum. . . .

"None of the above should be construed in disparagement of the less positive type of displacement meter. Its simplicity and low cost enable it to stand alone in its field of application. Our purpose is to secure authoritative nomenclature for the two distinctive types. Then each may rest on its own merits without confusion. . . ."

To summarize (with the dogmatism of brevity): one view holds that the distinction between "disk" and "piston" should be ended; the other claims that this distinction is insufficient and that the disk type should be excluded from the élite "positive" class.

Which is right?

To some extent, both; from a realistic standpoint, neither. This is the conclusion reached by taking a good look at the liquid displacement meters that are being produced and considering also those that could be made.

If the reader will scrutinize Figs. 23-20 to 23-40 for possibilities of leakage and slippage, he will discern that there is no sharp line dividing meters that are of positive design from meters that depend entirely on small clearances between rigid moving elements and rigid walls, that is to say on the closeness of manufacturing tolerances. It will be seen that in design and construction, in theory and practice, there are *degrees* of "positiveness." It would indeed be possible to establish a continuous scale of infinitesimal gradations, from an ideally positive meter to a "displacement" meter with such large clearances that its registration curve has no "flat" portion. ("Flat" could be defined as lying between ± 0.5% anywhere along the volume abscissa and ± 10% anywhere along the rate ordinates). The basis for such a scale of the figure of merit, with regard to positiveness alone, would of course be the registration curve—not necessarily the intrinsic accuracy of the meter being graded. At one extreme would stand a design which has never been commercially produced, namely a piston meter which could measure any fluid, even hydrogen, without leakage or slippage. The other extreme would characterize an equally inexistent kind of meter: one having a plunger or a piston or a disk (but not a velocity-impelled rotary element) with intolerably excessive clearances—a meter, in fine, belonging neither in "Class 1.2—Volumetric" nor in "Class 2.1—Current"—a meter, therefore, belonging neither in the positive division nor in the inferential division.

It follows that if a change in the generally accepted A.S.M.E. scheme became necessary in order to solve this controversy, it would have to amount to nothing short of moving *all* piston and disk meters out of the "positive" division. But their transfer "out of the positive into the inferential" might be thwarted, and we would then have a new intermediate division: "Displacement." But some volumeters (*e.g.*, the tank type for liquids and the valveless wet drum type for gases) do belong in the "Positive" division. So we would either have to discontinue the "Volumeter" class, or make it straddle the "Positive" *and* the "Displacement" divisions by assigning some volumeter types to the first division and other volumeter types to the intermediate division.

This having been done, unforeseen complications would arise and new controversies spring up, each worse than the one before, until the A.S.M.E. Report would become a patchwork. The condign dénouement would be a Dictatorship.

All this may sound far-fetched, but a line of reasoning *ad absurdum* was needed to demonstrate: (1) that since the various liquid meters in question do not arrange themselves into mutually-exclusive categories, *any* scheme of classification must be a compromise; (2) that to discard the A.S.M.E.'s compromise *classification* for a purely scientific *gradation* would be impracticable.

After noting the directionless course of this controversy in trade papers, technical journals, meetings, etc., one is tempted to drop the rôle of neutral observer and to point out that liquid volumeters do in fact divide themselves into two mutually exclusive categories: the gravitational and the displacement. (That some gravitational meters are weighers and not volumeters makes no difference. The headings between quotation marks in Table XXIII-1 show one way of disposing of this complication.) The outstanding fact is that no displacement meter is ideally positive. But as long as volumeters are generally

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The plant is located at 144 Pomeroy Street, New Cross, London, and consists of an office building and a new two story factory building of modern construction. The factory is completely equipped with machinery, tools and testing equipment, and with British employees especially trained and skilled in the art of instrument making. It is prepared to manufacture and service the complete line of Bristol's indicating, recording and controlling instruments.

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

361 Stroboscopic Meter. Circular L 20560 on a new portable standard testing any make of meter. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

362 Fluid Meters. 24-page Bulletin No. 300 describes and illustrates a new line of fluid meters for steam, water gases, oil, brine, etc. Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio.

363 Switchgear. 12-page circular GEA-1661, on Metal-Clad Switchgear, Type MI-6. General Electric Company, Schenectady, N. Y.

364 Watthour Meter. 4-page Circular 20561 on Type OC Detachable Watthour Meters for outdoor and indoor use. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

365 The Sperryscope. Vol. 6, No. 10 features the following articles: Flying the Ocean is An Instrument Job; Danish Defence Against Aircraft; The transport Plane—1933 Model, etc. Sperry Gyroscope Co., Inc., Brooklyn, N. Y.

366 X-Ray Camera. Leaflet on apparatus for making X-ray photographs by the Debye-Scherrer and Seeman-Bohlin methods. Kipp & Zonen, Delft, Holland.

367 Monochromator. 4-page circular describing a glass double monochromator. Kipp & Zonen, Delft, Holland.

368 Exposure Meter. Form No. 83 describes Electrophot photoelectric exposure meter for all cine photography. J. Thos. Rhamstine, 500 East Woodbridge St., Detroit, Mich.

369 Cenco News Chats. Articles in the April 1932 issue of this publication are: A Study of Wire Gauzes for Use Over the Bunsen Burner; High Melting Point of Sillimanite Leads to New Uses; The Latest Development in High Vacuum Pumps, etc. Central Scientific Co., 460 East Ohio St., Chicago, Ill.

370 Electric Heat. Immersion units for oil heating are described in Leaflet TB-30. Harold E. Trent Company, 618 N. 54th St., Philadelphia, Pa.

371 Hyperpyrexator. Circular on hospital cabinet for controlling a patient's body temperature within close limits. The Electrical Research Laboratories, 3703 Baring Street, Philadelphia, Pa.

372 Gages. Transparent Draft Gages; Dwight CO_2 Indicators; complete combustion testing outfits are described in a new circular just issued by the F. W. Dwyer Mfg. Co., 565 W. Washington Blvd., Chicago, Ill.

373 Polarization Photometer. A circular identified as List P. 26 describes Martens Polarization Photometer with sphere illumination device for measuring the hiding power of paints. Akatos, Inc., 114 Liberty Street, New York, N. Y.

374 Exposure Meter. Circular N 1 describes a Universal exposure meter for still and motion picture cameras. Weston Electrical Instrument Corp., Newark, N. J.

375 Magnetrole Relay made up of an especially designed glass tube is described in a circular issued by the Hart Mfg. Co., Hartford, Conn.

376 Extensometer. Bulletin No. 40 describes and illustrates the scratch extensometer. Baldwin-Southwark Corp., Paschall Station, Philadelphia, Pa.

377 Astronomical Instruments are described in a 15 page booklet which is distributed with the compliments of the American Askania Corp., Chicago, Ill.

378 Switchboard Instruments. Catalogue L. 20545 describes type **H switchboard** instruments, a.c. and d.c. radio-frequency, and rectifier types. Westinghouse Electric & Manufacturing Co., Newark, N. J.

379 Flow Meters. 32-page bulletin issued by the Cochrane Corp. of Philadelphia, Pa., describes the Cochrane high torque flow meters.

termed positive, the nutating disk type seems to be as much entitled to this qualification as is the piston type. What is of interest to the user is to know that *some forms of the piston type depend more on clearances between fixed walls and displaced members than does the usual form of the disk type.* Hence the deliberate distinction in Table XXIII-1 between the reciprocating piston form, which *can* embody self-sealing rings, and other forms, by usage termed "piston," which do not.

This distinction is based on design. The construction of the various makes, and the workmanship of individual meters, particularly around the valves (where leakage may offset the positiveness of the piston), are other factors contributing to the degree of positiveness. Users should take them into consideration, but it is recommended that registration curves be obtained, since *such curves are the true criteria of positiveness.* Not only registration tests but complete calibrations should be made, if possible under service conditions and in any case with the fluid to be metered. See §5.

Finally, positiveness is not the only basis of evaluation: pressure-loss characteristics, possibility of adjusting the register speed, initial and running costs, effects of changes in the physical properties of the metered fluid, and other considerations, should not be lost sight of in the flurry over pistons and disks.

POSITIVE LIQUID METERS

4. Weighing Meters

(a) Characteristics

Though capable of measuring extremely small flows, these devices are made up mostly in large models which cost much less than other equally accurate and reliable meters of equivalent capacities, so that many are used where it is immaterial whether the weight or the volume of the metered fluid be registered. However, the fact that these meters give the weight of the fluid regardless of variations in its density makes them the first choice for many plant and field applications. They are meeting with favor in the chemical and food industries.

Single-tank weighers operate intermittently, and when the inlet flow rate is nearly the capacity of the meter and *varies,* the error due to the tripping interval may exceed the correction if such correction has been adjusted (or built-in) for "normal" flow during each tripping. With a plurality of tanks this and other cyclic errors are minimized but mechanical complications are introduced, increasing first and maintenance cost.

An inevitable limitation of weighers is that they read in large units which cannot be subdivided.

As against this, weighers are positive at all rates of flow up to capacity, since "every drop is caught." Moreover, true weighing meters are affected by temperature changes only to the extent that such changes can affect their scales. Theoretically, an equal-beam scale requires no temperature correction and actually the temperature errors are negligible in the case of all weighing meters that trip when the metered fluid balances a weight.

Accuracy depends on the same weight being balanced at each cycle, therefore any deposit, scale, etc., which makes the receiving container heavier than it was at calibration will make a weigher read "fast." However, muddy liquids that would clog volumeters other than tank types, or liquids carrying grit that would wear out pistons and disks, are satisfactorily measured by weighing meters, provided only that the quantity of liquid or mixture which adheres to the container walls instead of being dumped is of practically the same weight in all successive cycles. Viscous fluids can be metered accurately if they are true fluids, but viscous liquids or mixtures, such as thick syrups, aggregates, etc., that would leave a *variable* amount undumped, cannot. Of course, this inaccuracy may be overlooked when other advantages are sought.

Since the isolated quantity and the balance weights are both weighed in air, and the former displaces a larger volume of air, changes in air density affect accuracy—but only to a negligible extent.

Installation and maintenance are simple and inexpensive on the basis of the large quantities usually metered. Calibration consists essentially of weighing accurately a single discharge. Variance in the weights of successive discharges at constant flow rate should not be appreciable. If it is, the accuracy of the scale with which the discharge is weighed should first be checked up.

The weight of a single discharge is the meter constant. This constant can usually be adjusted with precision by simply moving small counterweights.

The overall loss of head is usually the actual altitude difference between

inlet and discharge points. Some enclosed models regularly furnished can withstand moderate working pressures, say up to 10 lb. gage. Stronger enclosures are built to order. The outlet absolute pressure of enclosed models must always be less than inlet absolute pressure minus loss of head.

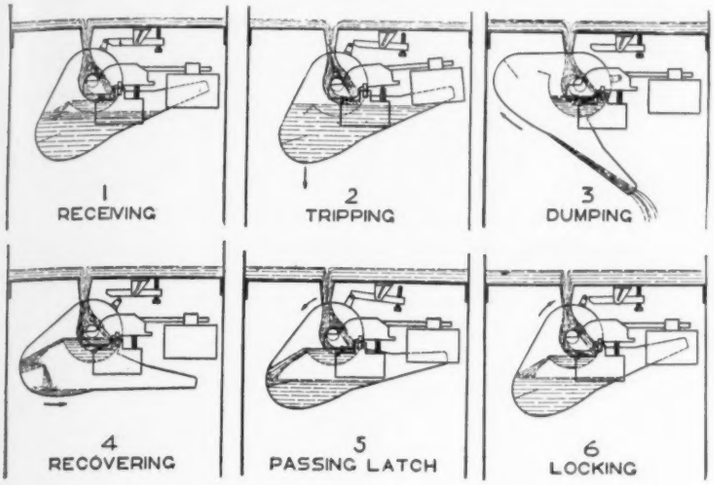

Fig. 23-5

(b) Commercially Available Models

Cochrane Corp'n. Fig. 23-5 shows the design and operation of a typical Cochrane unit. This meter

"actually weighs the liquid by balancing a bucket against a weight on a scale beam. The bucket rests upon the beam by frictionless trunnions, while the beam is supported on knife-edge bearings. . . . When a certain weight of liquid has accumulated in the bucket, the latter sinks until it escapes a latch, and then quickly turns over and discharges its contents. During the time that the bucket is rotating, the inflowing liquid is received in a detaining chamber. As soon as the bucket has discharged, it swings back so that the liquid in the detaining chamber flows into the main bucket, which thereupon proceeds to revolve slowly to its initial position. . . . The accuracy is within 1% at all rates of flow up to the maximum."

Fig. 23-6 shows an open-tank Cochrane model, designated as "portable," which is made in sizes from 15,000 to 40,000 lb. maximum hourly water rate. The smallest size is 29″ wide, 36″ long and 50″ high; the largest has minimum dimensions of 38″x44″x58″. Enclosed models come in corresponding capacities and with sheet steel or cast iron shells, the former good for 1 lb. max. working pressure, the latter for 10 lb.

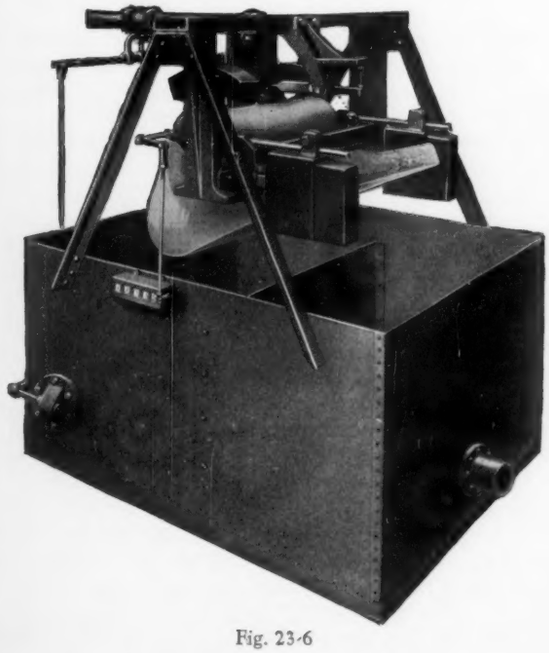

Fig. 23-6

380 Parallel Resistor. Ohmite Manufacturing Co., 636 N. Albany Ave., Chicago, Ill., announces the publication of a parallel resistor chart which eliminates calculations arising from the use of resistors in parallel.

381 Flow Meters. Catalog No. 2201 gives many new features of the Brown Mechanical Flow Meter. The Brown Instrument Company, 4482 Wayne Avenue, Philadelphia, Pa.

382 Fluid Meters. An attractive 24 page bulletin, identified as No. 300 describes a new line of fluid meters manufactured by the Bailey Meter Company, 1050 Ivanhoe Rd., Cleveland, Ohio.

383 Sieves. A new six page folder devoted to the End-Shak Testing Sieve Shaker and the U. S. Standard and A.S.T.M. Standard Cornerless Testing Sieves, has just been printed by the Newark Wire Cloth Co., 351-365 Verona Ave., Newark, N. J.

384 Batchers. Full automatic and manual weighing type cement batchers are described in a circular by the Fuller Company, Catasauqua, Pa.

385 Grade-O-Meter. Bulletin No. 12 describes this instrument which is used by makers of grinding wheels to measure the grade of same with scientific precision. Abrasive Engineering Corp., 8605 Puritan Ave., Detroit, Mich.

386 Controllers. Catalogue 1603, Section-1 intended to present the process cycle controllers and accessory equipment offered by the Bristol Co., Waterbury, Conn., to aid the art of complete automatic control on process work.

387 Paper Testing Apparata. A 17 page booklet on the following: Bekk Smoothness and Porosity Tester; Riesenfeld-Hamburger Dusting Tester; and Riesenfeld-Hamburger Stiffness Tester. R. Fuess, Inc., 245 West 55th St., New York.

388 Taylor. Among the articles listed in the October 1932 issue of this publication are: Science Reveals Mystery of the Desert's Phantom Orchestras. Prima Donna of "Singing Sands" Found in Arabia; Destructive Force of Hail; Hailstones Are Weather Wonderworks; etc. Taylor Instrument Companies, Rochester, N. Y.

389 Refrigeration Controls. Two circulars, one identified as Page L 29 describing Type L 414 Refrigeration Pressure Controls, and the other identified as Page T 13, describing Type T414 Refrigeration Controls. Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

390 Boiler Controls. Type L Pressuretrol are pressure operated electric switches designed to serve as limit controls for steam boilers automatically fired, and these are described in circular identified as Page L 22. Minneapolis-Honeywell Regular Co., Minneapolis, Minn.

391 Microphotometers. Booklet MF 33 illustrates the Moll recording microphotometer which is intended for the investigation of photographed spectra. Kipp & Zonen, Delft, Holland.

392 Aneroids & Barometers. Catalogue No. 38 of the G. Lufft Co., Stuttgart, Germany, describes altitude aneroids, and catalogue No. 39 issued by the same company describes barometers and weather sets.

393 Humidistat. This instrument described in a small circular has been designed to meet the demands for an instrument to control humidity, using human hair as the hygroscopic element. Julian P. Friez & Sons, Inc., 4 North Central Ave., Baltimore, Md.

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INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

Noise and Vibration Engineering. S. E. Slocum. D. Van Nostrand Co., Inc., New York, 1931. 171 pages. Cloth, 9½x6 inches. $2.75.

Although purporting to be a pioneer effort in the direction indicated by the title, this book really covers only a part of this vast and important phase of modern engineering. This is readily understood when the point of view from which the book is written is appreciated. Mr. Slocum's main interests have been concerned with the construction of buildings, with an eye to minimizing vibration. This, then, naturally narrows the field to a discussion of transmission of waves through soils and to chapters concerned with vibration isolation. The first section emphasizes that side of soil dynamics which it is important to recognize, and hence has its proper place. The sections on vibration insulation, however, rather than indicate the fundamental similarity of vibration isolation constructions, proceed as if the author wished to emphasize the differences in the various constructions used in buildings, subways, road beds, etc. The important subject of the damping characteristics of materials is not given the treatment this subject demands, particularly as to the criteria for the judging of the damping efficiencies of various materials. The question of noise, *per se*, is given an adequate treatment again insofar as the architect and builder are concerned. The last section of the book contains the "mathematical ground work," and here again it must be realized that it covers only the simplest of well-known cases. The impression then that one carries away after having perused this book is that it has been written for those people who are to be impressed with the importance and scope of the subject, rather than to instruct those who wish to become expert in it.—M. Stone. [6.1] **B**

On the Formation and Dispersion of Oil Sprays. By Kalman DeJuhasz, O. F. Zahn, Jr., and P. H. Schweitzer. Pennsylvania State College Bulletin No. 40, 1932. 86 pages, 6 x 9". Price $1.00.

The behavior of fuel sprays is fundamental for all fuel injection engines. The conditions under which the spray is formed and dispersed in the cylinders, the influence of the character of the fuel oil, the form of nozzles and the pressure under which the spray is formed, are investigated experimentally in a most scientific fashion. From the result of these investigations curves and diagrams are derived for practical utilization so that a designer can form a good idea of the arrangement of the vital parts of fuel admission and combustion and the best suitable pressure. For the engineer who wants a deeper insight into this matter, purely theoretical appendices are added where the mechanism of the disintegration of the spray is treated mathematically; it has been considered as a phenomenon of probability, a rather different way from the usual treatment, and the authors establish the relationship between the magnitude of aberrations of the droplets in their path from the mean aberration. A list of 54 English and German references completes the useful little volume. M. Hartenheim (12.1)-**B**-

Instead of a plain counter, a combined counter and recorder is optionally available which produces charts such as Fig. 23-7. The pen moves radially a short distance for each discharge and reverses at every fifth discharge, so that each complete "wave" represents ten bucketfuls. (The chart illustrated

Fig. 23-7

shows 73 discharges between 8 and 9 a.m., 17 between 9 and 10 a.m., none between noon and 1 p.m., etc.)

These meters should not be used continuously above 70% of rated capacity, and peak loads should not exceed that rate of flow which causes the bucket to tip more than six times a minute.

5. Liquid Volumeters—Standards and Calibration

Primary and inspectors' standards of liquid measure need no discussion in this handbook: the Bureau of Standards and other bodies having made detailed information available, and most of the essential data being readily found also in various manuals on the reader's bookshelf.

The familiar Sealers' five-gallon can is a well-known example of a standard of liquid measure. The simplest procedure, then, consists of filling such a can—or a 5000-gallon calibrated tank—through a volumeter and noting the meter's registration.

Volumetric metering work, however, differs radically from "plain measuring" in several respects of which the most important are: (1) the time element, (2) the pressure loss.

(1) Although *rate of flow* is not the all-important factor as in inferential meters, provision for its measurement must be included even on the crudest test bench, in order to determine the characteristics of the meters at extremely low rates and at overloads.

(2) *Pressure loss* has to be determined for several reasons:

a) It is the most important characteristic—apart from accuracy—of meters intended for applications where the available head is low and where rapidity is essential, as in dispensing.

b) Where pressure constancy is desired on the outlet side, a meter showing an excessive loss at peak load is either too small or otherwise unsuitable.

c) The pressure-loss curve at all rates of flow from zero to a load that "races" the meter is often the basis of re-rating a meter—that is to say, determining its proper rather than its nominal capacity.

d) In comparing similar volumeters, the pressure loss readings at equal loads show which meters have the least friction and will therefore serve longest and require attention least frequently.

e) Finally, the engineer or industrial executive bewildered by such controversies as that between advocates of "positively leakless" and of "easy-running, low-loss" volumeters cannot ascertain all facts for himself unless he can plot the pressure-loss curves for all rates of flow at various line pressures.

The nature and number of the tests depends not only on the data sought —some of which are listed above—but also on the type of volumeter tested. For example, open volumeters of the tank or drum type require neither the pressure loss test nor the determination of the minimum flow that causes

registration. On the other hand, closed meters intended for metering fluids under pressure may be required to undergo a static pressure test in addition to items listed above.

Many special test procedures will suggest themselves to the using engineer who desires to reproduce certain service conditions. Even installation condi-

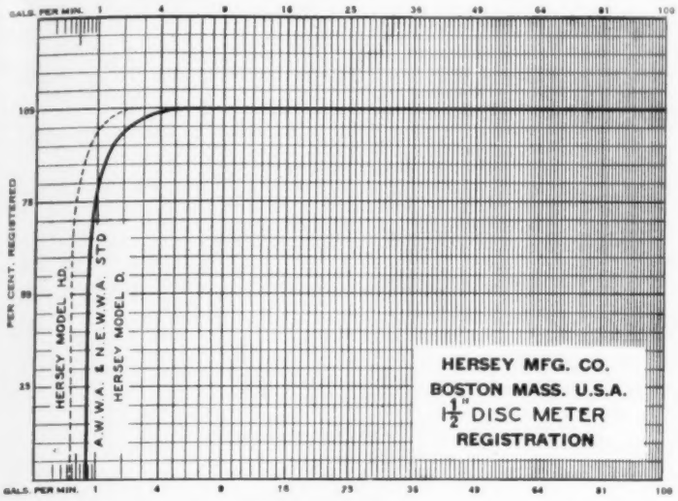

Fig. 23-8

tions sometimes deserve to be taken into account, and in this connection we need only mention the "bending test" for meters that are supported by the inlet and outlet pipes: this consists of calibrating a meter first unstrained and then subjected to strains tending to warp its case. Some meters exhibit increased friction (manifested by increased pressure loss) under comparatively small distortion, and their mechanism may stick altogether if the inlet and outlet pipes are several feet long and the whole assembly rests on two points of support ten or twelve feet apart.

Registration Check

Before taking up calibrations, which always involve a plurality of readings, a few words on the simple test for *accuracy of registration* of meters discharging to atmosphere may not be amiss. Too much emphasis cannot be laid on the importance of using a *standard*. Small measures are readily available but for large meters it often is necessary to build "calibrated" tanks. Such tanks should be calibrated with care. One meter manufacturer complains, in a private communication to the author, that "rarely are customers able to test a meter . . . closer than ½% or sometimes 1%." A good way of assuring precision is to build a tank with a narrow neck—shaped somewhat like an inspector's measure—and run tests at a temperature close to that at which the tank was calibrated. (For commercially available calibrated tanks see below under Equipment.)

Capacity Test

This consists of determining the pressure-loss when the rate of flow corresponds to that for the "size" or "capacity," and also—optionally—at other rates. The capacity test need only be made on one meter out of a lot that are all similar, since it is essentially a test of design to check up on the nominal rating; but when a meter properly rated for one liquid is intended for the measurement of another liquid, it is necessary to run a special capacity test if this other liquid is of different viscosity, density or homogeneity.

Static Pressure Test

After this test, a calibration should be run over again, so that any impairment of accuracy due to distortion, or other permanent effects thereof, may be discovered.

Calibration

This consists of one or more series of tests for accuracy of registration. If the meter discharges to atmosphere, one series of tests made at various rates of flow may suffice. If the meter is for a pressure line, one series may suffice, with the inlet pressure corresponding to that of the intended service and with a valve downstream to regulate flow, but two additional series—one at a higher and one at a lower pressure—may be specified. In all such investigations of

Second A.S.T.M. Exhibit of Testing Apparatus and Equipment

The American Society for Testing Materials announces that it will hold the Second Exhibit of Testing Apparatus and Equipment in conjunction with its Thirty-Sixth Annual Meeting at the Hotel Stevens, Chicago, June 26 to 30, 1933.

In response to many requests following the First Exhibit in 1931, the scope of the Second Exhibit in 1933 will be enlarged to include not only testing apparatus and machines, but also recording and control apparatus, laboratory equipment, measuring instruments, and the like, which are used in conjunction with the testing of materials.

The Society will maintain the scientific and broadly educational atmosphere of an exhibit consistent with the technical nature of the Society's activities, so well established in the First Exhibit.

Research laboratories and committees of the Society are again being invited to exhibit special apparatus they have developed which is not produced commercially.

In consideration of the greatly enlarged attendance of engineers, technologists, and scientists expected during Engineering Week, and of the desire expressed by some exhibitors for greater latitude in admitting interested visitors and guests of exhibitors, the Society will so regulate admission to the Exhibit as to permit attendance, at minimum inconvenience and expense, of all who are genuinely interested in the Exhibit. However, as in 1931, there will be no general public admittance to the Exhibition Hall.

The Stevens Exhibition Hall, unsurpassed in facilities for an exhibit of this type, will again be used for the A.S.T.M. Exhibit. Booth units will be approximately 10 by 13 ft. The Society is pleased to say that, despite the demand for exhibition space during the Chicago Fair and the general tendency for price increases under such conditions, *there will be no increase over 1931 rates for exhibit space or hotel accommodations.*

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The C. F. Burgess Laboratories, Inc. of New York City announces the acquisition of a substantial interest in the United Electric Controls Company, 69 A Street, Boston, Mass., manufacturers of a full line of thermostats and limit controls for oil burners and other automatic heating devices. The newly elected Board of Directors of the United Electric Controls Company consists of: W. D. Cashin, President; B. W. Dezotell, Vice-President and Secretary; James Carter, C. F. Burgess, C. H. Burgess, and Jackson Burgess.

◆ ◆ ◆

Dr. Willis Rodney Whitney, organizer and for thirty-two years director of the research laboratory of the General Electric Company, retired from that position owing to poor health on November 1. He was succeeded, by appointment of Gerard Swope, president of the company, by **Dr. William David Coolidge,** senior associate director of the laboratory. Dr. Whitney continues as vice president in general charge of research.

Dr. Coolidge, the new director, is a native of Hudson, Mass. He was trained at Massachusetts Institute of Technology and the University of Leipzig. He was appointed assistant director of the laboratory in 1908, and associate director in 1928, a title also held by Dr. Langmuir.

NEW INSTRUMENT CONCERN

The Parr Instrument Co., Moline, Illinois, has recently been organized by Mr. H. L. Parr and other associates of the late Professor S. W. Parr and has acquired the scientific instrument business of the Burgess-Parr Company. The new organization is fully equipped to manufacture and provide to the chemical laboratory market the entire line of Burgess-Parr laboratory apparatus including coal calorimeters, sulphur bombs, turbidimeters, apparatus for catalytic hydrogenation, equipment for melting point determinations, goggles for glass blowers and special chemicals for sulphur, carbon and calorimetric determinations. In addition, new developments will be introduced at a later date.

H. L. PARR

Burgess-Parr Company will retain its headquarters at Moline, Illinois where it will continue the manufacture of Illium castings for the chemical process industries.

Adolph Lomb, vice-president of the Bausch & Lomb Optical Company, died on September 30, at the age of 66. The eldest son of Capt. Henry Lomb, co-founder of the Bausch & Lomb Optical Company, he had been connected with that firm for 53 years. In addition he was identified with a number of scientific and patriotic societies. He had been treasurer of the Optical Society of America since its inception and one of its most beneficent financial supporters.

Born in Rochester in 1866, Mr. Lomb graduated from the University of Rochester in 1892, and also took advanced work at the Massachusetts Institute of Technology and the University of Berlin, Germany. He was unmarried.

The specifying of instruments and devices for measurement, testing and control starts with engineers, work managers, research engineers, test engineers, consulting engineers, etc.

INSTRUMENTS

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INSTRUMENTS
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meter performance, the tests at low rates of flow furnish the most interesting data and should be sufficient in number to permit plotting the low-rate end of the curve. Plotting—not guessing! (And—for meters required to measure small flows accurately—not suppressing!) In this connection, the use of a quadratic or logarithmic scale for the abscissa is recommended. See Fig. 23-8.

Note how readily the manufacturer's specification (or expectable performance) of the "HD" meter below 4% of capacity flow may be compared with the joint specification of the American Water Works Association and New England Water Works Association. This official specification, as worded, permits this particular size of disk meter to show a 10% error at 1.5% of capacity flow. Note also that the manufacturer does not suppress any portion of the curve but candidly publishes the fact that when the flow is less than 0.35% of capacity flow, the "HD" meter is not guaranteed to register at all.

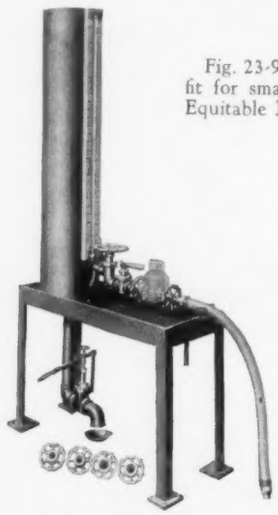

Fig. 23-9. Registration test outfit for small meters. (Pittsburgh Equitable Meter Co.)

Meters with adjustable by-passes need not be tested at extremely small flows, because they are destined for dispensing service, and also because the dribble test has no practical signficance in the case of such meters, for it is obvious that there will be no registration when the flow is less than that which is by-passed, that the "error" will be 50% when the rate is twice the by-passed flow, and so on. This does not mean however, that the calibration of by-passed meters can be slighted: on the contrary, the registration curve for any particular liquid should be plotted from at least four points starting with 10% or 15% of capacity flows; the by-pass adjusted to bring the normal flow portion closer to the zero error (100% registration) line; and this procedure repeated until the flat portion of the curve practically coincides with the zero line.

The same recommendation holds true with regard to changing gears in the intermediate train when a meter is to measure a liquid of different gravity, etc., or to compensate for increased slippage.

In short, almost any "displacement" meter—no matter how imperfectly "positive"—can be made to give excellent registration within a surprisingly wide range of flows if a competent operator tests it thoroughly, uses accurate equipment, interprets the results and makes proper adjustments.

The above does not apply to all piston and disk meters: Old meters of such types, found to register different volumes when equal volumes of the same liquid are passed successively under identical conditions at normal rate, should either be condemned, sent to the shop, or relegated to services which call for a limit of error in excess of the variance. Time can be saved, therefore, if all meters suspected of giving inconsistent readings are first tested for variance.

"It is seldom that we find a book we can so heartily recommend . . . Must be read to be appreciated."—*Heating and Ventilating*

"Done unusually well . . . A great deal of valuable and practical data . . . of much importance." — *Maintenance Engineering*

—Thus does the technical press acclaim Béhar's new handbook of industrial

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NEW INSTRUMENTS

Recently Developed by Manufacturers

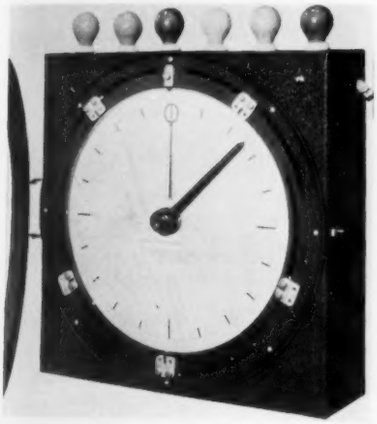
Time Signaling Device for Banbury Mixers

Farrel-Birmingham Corp.

THIS device signals the operator by flashing a light, and by ringing a bell or gong if desired, as various stages of a mixing operation are completed, thus insuring uniformity in the compounding of stock.

When the chemists have laid down the schedule to be followed, the paper chart is marked at the intervals where it is desired to flash a signal. The contact points are set to correspond to the marking on the paper chart and the cover of the instrument closed and locked. Thereafter, until changed, the instrument will signal as desired, it being only necessary for the operator to set the pointer at zero at the beginning of each batch.

The circuit is arranged for 110 volts, a Telechron motor being used to drive the mechanism, with a switch for disengagement. The transformer to provide 110 volts, single phase current is connected to the primary circuit of the Banbury mixer motor so that the Telechron motor driving the instrument will stop if power fails. The lights furnished with a standard instrument are of varied colors for distinguishing the different stages of the process.



The pointer is hinged to permit easy placement of the unslit chart and is driven by friction engagement so that it may be set to zero, either forward or backward. It registers the position of the rotating contact arm, which makes connection with the adjustable contact points for the successive signals. It revolves once in 10 minutes or once in 20 minutes, a reversible pinion being easily set for the desired speed. The chart diameter is 16¾" (circumference 52.62"). Therefore the pointer tip travels 2⅝" or 5¼" per minute, depending on the speed setting. The adjustable contact points may be grouped closely together if necessary.

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Compact Radio Frequency Monitoring Unit

Western Electric Co.

ENABLING radio stations to maintain a constant check on their frequencies, a monitoring unit, designed by Bell Telephone Laboratories, measures only 12¼ by 13½ by 17 in. It can be connected into any stage of the transmitter or used entirely apart from it by means of an antenna. This flexibility is made possible by the fact that the input may come from either a modulated or unmodulated source without affecting the accuracy of the device.

The impulses from the transmitter pass through a stage of amplification and into a detector tube. The unit contains a quartz crystal oscillator which oscillates at the assigned carrier frequency. The output from this oscillator is also passed through a stage of amplification and fed into the same detector. The output of the detector contains the beat note or difference frequency. This difference frequency is registered on a visual indicator kept under observation by the station's technician.

The monitoring unit may be connected to ordinary radio receiving sets, except those of the super-heterodyne type. This makes it possible for a station executive, for example, to keep his transmitter under observation by attaching the unit to a radio receiver in his home or office.

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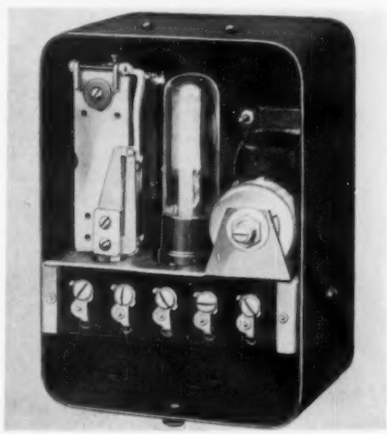
New Midget Photoelectric Relay

General Electric Co.

DESIGNED for installations where practically complete interception of the light beam is made, since changes of light intensity of at least 50 per cent are necessary for successful operation, this new unit is particularly adaptable to counting, inasmuch as the relay contacts will handle directly the usual types of magnetic counters. It will operate on light impulses of 1/15 sec. duration and should also find many applications in the limit switch field.

The new relay, designated as the CR7505-K1, consists of a phototube, a Pliotron amplifying tube, a sensitive relay, an adjustable potentiometer, and associated apparatus, all mounted on a steel base. A drawn shell enclosing case is provided to allow mounting on a vertical support. The base assembly may be removed from the case by unfastening two screws, although the unit may be wired and adjusted without taking it from the case.

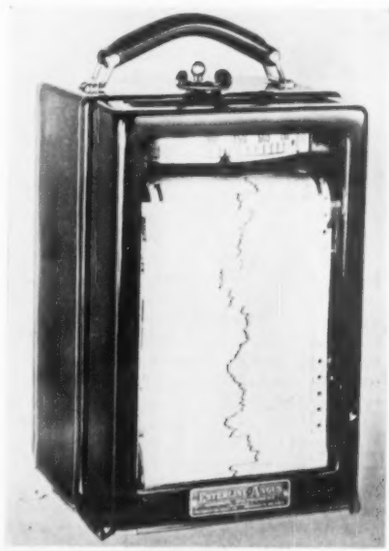
A cover, with one opening for the phototube and another for the potentiometer adjustment, is easily removed and may be replaced by one with an optical system, should the application require it.



New Low Range Recording Milliammeter

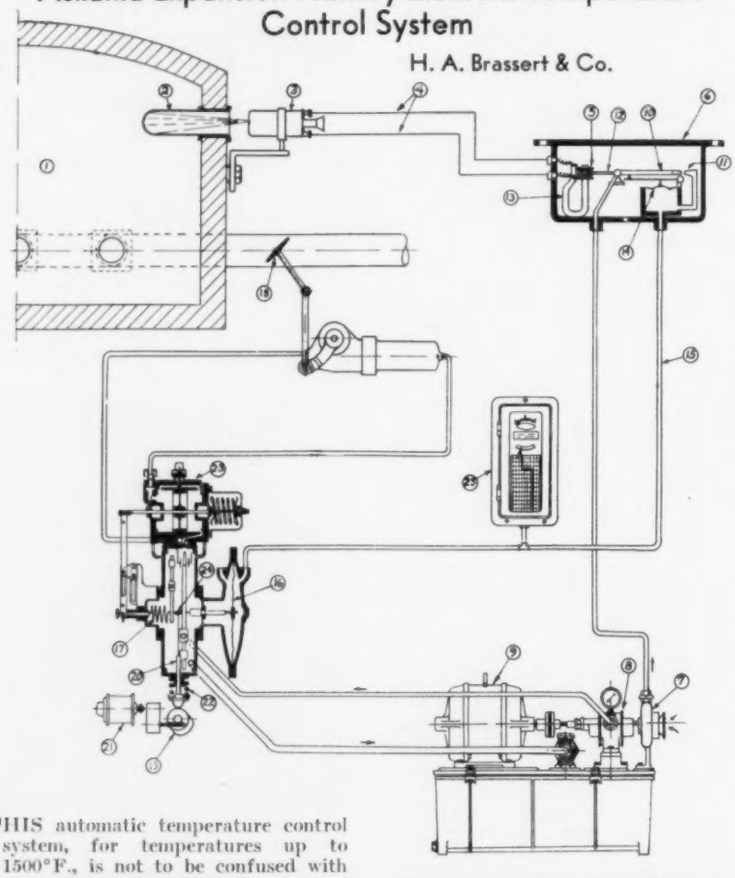
The Esterline-Angus Co.

A GRAPHIC milliammeter of the strip chart type having the exceedingly low range of 5 ma. for full scale is announced. It is direct-writing and contains no auxiliary amplifying equipment. The values are measured by a d'Arsonval element of high accuracy, which has sufficient torque to operate the writing pen over a chart 4½" wide. Continuously recording the current in the plate circuit of a vacuum tube, and adapted to recording modulation, volume-level, sound intensity, light intensity, vibration, and for any other purpose where an accurate record is required of the output of an amplifier, this instrument will be of special interest to radio, sound and projection engineers, and is particularly suitable for the monitoring of broadcast stations, public address or centralized radio systems, and sound-movie installations. Instruments are made in portable, wall and switch-board types, and for chart speeds of from ¾" per hour to 1½" per sec.



Askania Expansion Primary Element Temperature Control System

H. A. Brassert & Co.



THIS automatic temperature control system, for temperatures up to 1500°F., is not to be confused with plain regulators in which the thermal element is an expansion rod of the same general type. In this system the primary element actuates an Askania jet-pipe relay whereby a powerful hydraulic cylinder operates the valve on the heating (or cooling) medium line. A typical installation is illustrated. The regulator A is installed in a horizontal position at the point where the temperature requires to be controlled. The regulator is connected by two oil pipes H to the regulating cylinder J, the piston rod of which is, in turn, connected with the lever operating valve L on the main which supplies the medium used for heating and cooling. The resultant of the expansion of the metal pipe, B_1 and of the quartz glass tube B_2 is transmitted by a set of levers C to jet pipe D. Changes of temperature deflect the jet pipe from its central position and result in a movement of the operating piston. The temperature to be maintained can be adjusted by setting screw F, which operates a spring lever, changing position of fulcrum E. To guard against lag in the regulation, which results from the thermal capacity of the heating surface, a mechanical overtaking gear is provided, which prevents the "hunting" which would otherwise occur. The overtaking lever G is connected with the valve lever in such a way that each position of the stroke of the operating piston corresponds to a definite position of G. If, therefore, the piston has moved in order to correct the variation, the overtaking motion changes the setting at which the piston will move, so that the regulator is, in reality, set for a higher temperature than the original one. No further regulation will take place unless the temperature rises still higher or decreases.

The Spekker Steeloscope

Riehle Bros. Testing Machine Co.

POSITIVE detection, and in some cases accurate quantitative determination, of alloying elements, can now be made quickly and conveniently by a specialized spectroscope suitable for plant as well as laboratory. Developed several years ago and put to the test of 3 years' service, the Spekker Steeloscope is now being produced commercially by Adam Hilger, Ltd. in London and is available to American metallurgists through the above company. Its general appearance is shown in the illustration. The principle employed is examination of arc spectra. The observer first uses a pair of pure iron electrodes as a light source and then substitutes for one of them rods containing known amounts of various metals. A day's experience acquaints him with the appearances of all the spectra he need know in his routine work and he is able to *detect* various elements.

But in order to *measure* the percent of any of these elements, it is necessary to measure the intensity of a selected line in its arc spectrum. This procedure, formerly a delicate laboratory job, is now reduced to a simple matter of practical photometry by a new attachment, the "Instan Eyepiece," and the observer requires no more skill than does the user of an optical pyrometer of the disappearing filament type.

The field of view is divided into two parts, and a line of the metal sought may be brought into juxtaposition with a selected neighbouring line of iron. By turning a knob (geared to a scale) the intensity of the line of the alloying metal can be made equal to that of the iron line. The scale readings for a number of samples containing known percentage contents of the various metals provide data for a graph (usually a straight line) connecting the logarithm of percentage content with the scale reading. Unknown samples can thereafter be tested and the percentage content read off from the graph.

In general use one electrode is always formed by a substantial rod of pure iron and this is brought into contact with any shape or size of specimen to form an arc. Filings or turnings are easily tested by placing them into a metal cup of about 1" diameter and ⅛" depth which in turn is placed on a suitable piece of metal connected with one pole of the electric supply; the pure iron rod being brought into contact with the surface of the filings.

Following are typical results obtained with the Steeloscope:

Chromium. Less than 0101% can be detected and estimation made up to 4.0%. *Copper.* 0.097% has been detected. *Cobalt.* Discrimination is possible between 2.0, 3.0, 6.0 and 19.8%. *Molybdenum.* Discrimination is possible between 0.5, 1.0, 2.25 and 7.3%. *Tungsten.* Estimation up to 10%. *Vanadium.* Quantitative estimation is possible between less than 0.1% and 1.4%. *Manganese.* Rough quantitative measurements have been obtained up to 1.4%. *Titanium.* Titanium in filings has been detected at as low a content as 0.054%. Discrimination is easily possible between, 0.17, 0.64, and 1.9%.

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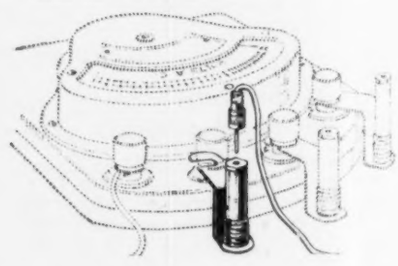
Fusible Jack Binding Posts

Littelfuse Laboratories

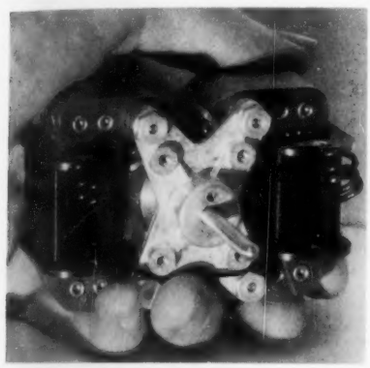
HOW to employ the correct size of fuse for each scale reading on multi-range meters, and still be able to shift readily from one range to another? This perplexing problem has at last been solved by the simple device illustrated: The Fusible Jack is secured under the binding post of the instrument, and the fuse is enclosed within the Bakelite barrel which is merely unscrewed to make fuse renewals. A solderless pin plug permits installation without the use of tools. The fuses used in this mounting are Instrument Littelfuses and come in 1/100, 1/32, 1/16, ⅛, ¼, ⅜, ½, ¾, 1, and 2 amperes capacity. On account of their quick-acting characteristics they afford protection to even the most delicate instruments.



Larger Shaded-Pole Motor

Barber-Colman Co.

SUPPLYING the demand for a shaded-pole motor to run at a slower speed than existing models with no sacrifice of starting torque or efficiency, Type YAk Barcol Midget Motor is a core-type motor of the same general design as its predecessors, except that it has four poles and therefore runs at approximately half their speed. Its "synchronous" speed is 1800 r.p.m. as compared with 3600 r.p.m. of smaller models. Actually, no-load speed is about 1700 r.p.m. due to necessary slip between rotor and rotating field. At full load the motor delivers 0.0035 h.p. at 1300 r.p.m. with an input of 23 watts at 115 volts 60 cycles. Starting torque is 0.2 lb./in.—very good for a shaded-pole motor. Current drawn when stalled is but little more than when running at full load, so that there is no danger of burning out through stalling.



Outside dimensions are 3″ x 2¼″ x 1″. The rotor is 1.1425″ in diameter and the hardened and ground shaft, which runs in "oilless" bearings, is 0.1845″ in diameter. Two field coils are used, wound on phenolic resin spools and connected in series. There are two shading rings on each of the four poles. The motor is durably built throughout and can be made to suit a variety of voltage and frequency requirements.

Barber-Colman Company has patents allowed and pending on this type of motor.

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Photographic Racing Timer

Western Electric Co.

A TWO-EYED motion picture camera which photographs the runners at the finish of a race and the precise time as they cross the line, produces a strip of slow-motion picture film which reveals the action of the runners in great detail and simultaneously records the readings of a chronograph to 0.01 sec. Known as the Kirby Two-Eyed Camera, the device was developed by Bell Telephone Laboratories for Electrical Research Products under the sponsorship of Gustavus T. Kirby, Chairman of the Olympic Games Committee and Chairman of the Advisory Committee of the I. C. A. A. A. A.

The timing standard is a tuning fork chronograph. Three concentric dials keep time, one registering minutes, another seconds and a third hundredth of seconds. These dials are set rotating by the hammer of the starter's gun. At the finish line the equipment comprises a 16 mm. motion picture camera capable of shooting 128 frames a second, operated as the runners approach the finish line. Through a double lens it photographs both the runners finishing and the time of each picture as shown by the constantly revolving dials. The photograph record of the time dials occupies about one-fourth of the film space.

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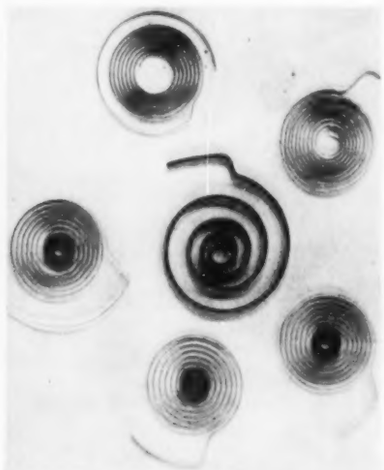
New Pre-formed Over-Looped Hair Springs

L-H-D Spring Corporation

INCREASING demands for hair springs possessing great accuracy not only in strength but also in form, so that they may be readily applied to the instruments for which they were designed, has been met by the types illustrated. It has heretofore been the custom to shape plain round hair springs by



hand as they were assembled into the instrument. Springs of the new over-looped type, as shown, are shaped mechanically before heat treatment. Assembly is thereby speeded up considerably; accuracy and strength built into the spring are maintained; risk of breakage is eliminated and appearance is improved. The cost of over-loop springs is no greater than for the plain round types. These same shapes are being applied to special types of helical springs where precision in strength and dimensions are required.

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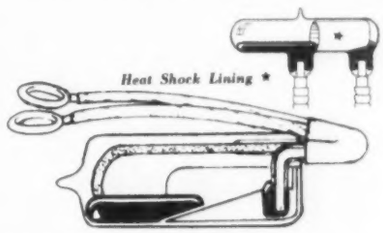
New Line of Mercury Switches

E. Machlett & Son

PROTECTION of the glass against the arc, by means of an inner sleeve or lining of ceramic material, is the feature of this new line, designated as "CER-AM-IC." Fig. 1 shows a type rated at 25 amps. which made a million breaks at 37½ amps. without injury. Fig. 2 shows a snap action switch with a nominal rating of 15 amps. at 125 volts



a.c. which is designed to withstand heavy momentary overloads on d.c. of as much as 700%, and which may be operated at 200 breaks per min. for an indefinite period.

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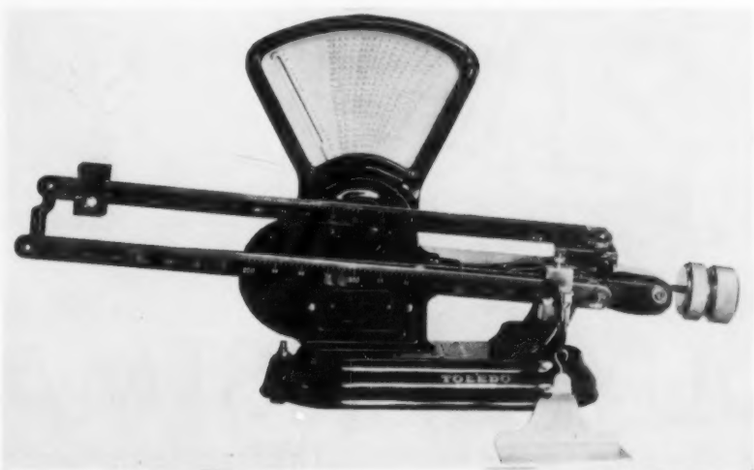
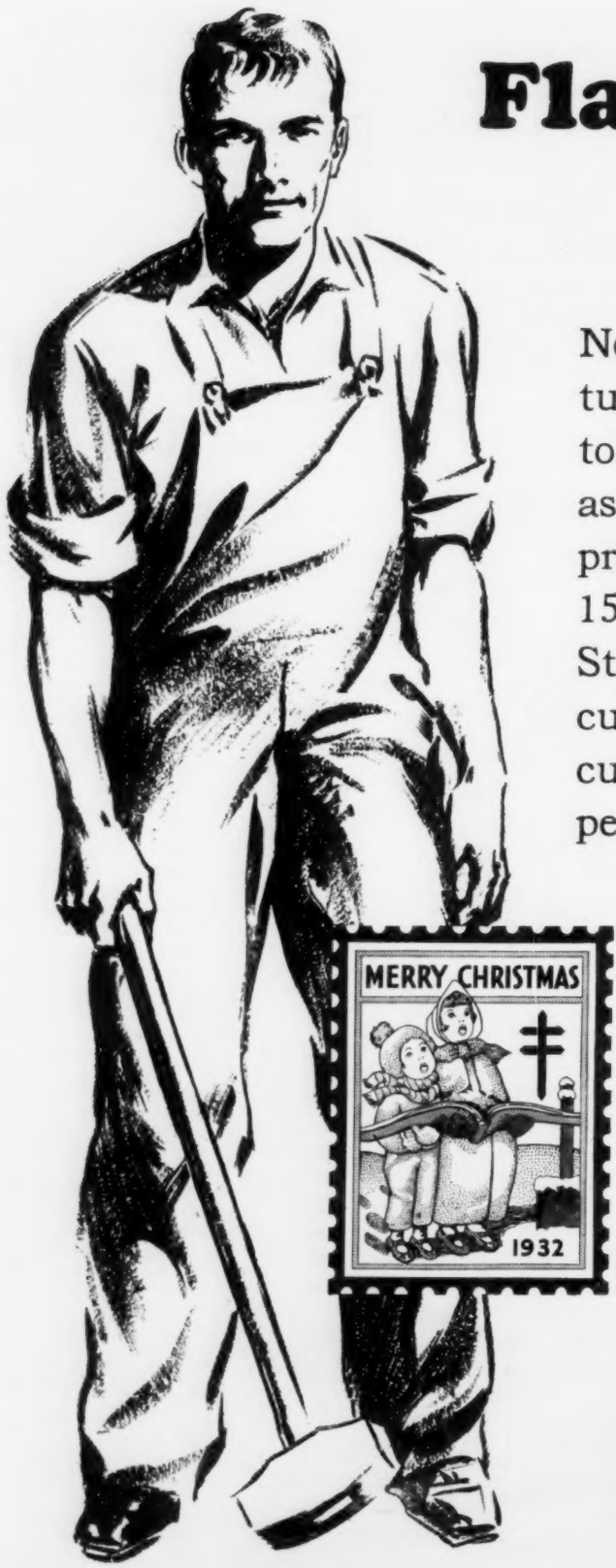
Variation Auto-Gage

Toledo Precision Devices, Inc.

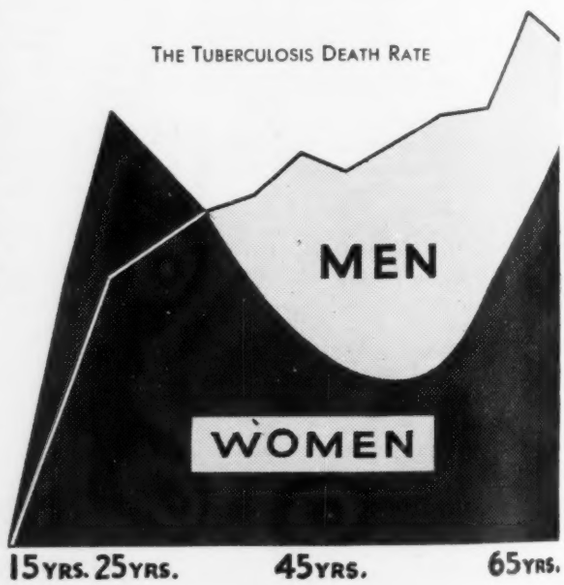
MEASURING changes in the physical characteristics of materials during processing, or before shipment and after receipt, has been difficult heretofore. The Toledo Variation Auto-Gage indicates the increase or loss of any physical property (elasticity, specific gravity, moisture content, etc.) in any material. It can also be used for counting small pieces, finding the unknown number of parts in a lot; in which case the number of pieces can be read directly from the chart. This device can be furnished with any chart needed, with calibrations in percent, elasticity, specific gravity, pounds and ounces. Any special commodity container can be supplied. The weight of the containers used can be tared out. Two sizes are available: for samples from 2 oz. to 3 lbs. and for samples from 4 oz. to 6 lbs. In some cases, no samples are necessary as the operation is carried out by a weight submerged in the liquid to be tested. For such operations, any weight desired to be suspended in a liquid can be furnished.





Flatten the Peaks

Needlessly, year after year, tuberculosis takes its great toll. No other disease kills as many persons in the most productive period of life—15 to 45. Examine the peaks. Startling? Yes, for tuberculosis can be avoided and cured. Help flatten these peaks. Your health tomorrow may depend on your assistance today.



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THE NATIONAL, STATE AND LOCAL TUBERCULOSIS ASSOCIATIONS OF THE UNITED STATES

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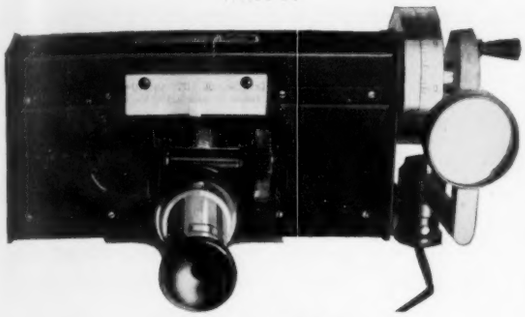
WITH A



PRECISION MICROMETER SLIDE

THIS newly designed instrument, with its accurate screw and other delicate parts completely enclosed in a steel housing, may be adapted to numerous purposes in the Laboratory or Shop, under the most adverse conditions. It is made in four sizes up to 4 inches and will accommodate any of our standard microscopes.

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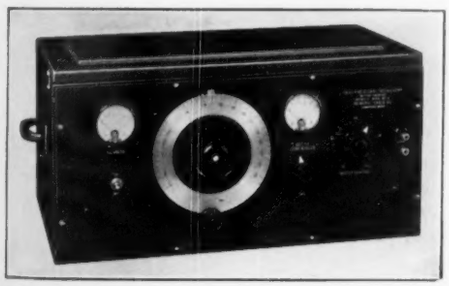

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build, gave entire satisfaction. The movement is put into operation by turning the block bearing the platform and the drum shaft bodily about 180° for which purpose a handle is provided. This has the effect of winding the ribbon on the drum, and putting the torsion springs under stress. Here again, as in the diaphragm motion, all the blacklash is eliminated. A clamping nut secures the block in both, the active and inactive positions, whilst there is an adjustable stop for fixing the amount of tension.

The lamp Y is a 6 volt motor car lamp focussed on a small hole by means of a condenser lens. This hole serves as a light point.

The diagram fills out well a 9x12 cm. (3.5x4.75 in.) photographic plate with a distance between the moving prisms of 12 cm. (4.75 in.) and a further distance to the plate of 60 cm. (23.5 in.). The calibration curve, showing a linear deflection, is given in Fig. 83d and a sample diagram, being disphased 90° to show the characteristics of the pressure rise, is shown in Fig. 83e.

In the optical indicator of von Gehlen (H. Maihak) shown in Fig. 84, the light ray is reflected 3 times which results in an unusually compact construction.[6] The cylinder and piston reach well into the space to be investigated. A cantilever spring *d* presses upon the piston rod, the upper end of which, by its motion rocks the "pressure mirror" *e* attached to a short lever. The "travel mirror" *f* is rocked by a small lever suitably driven by

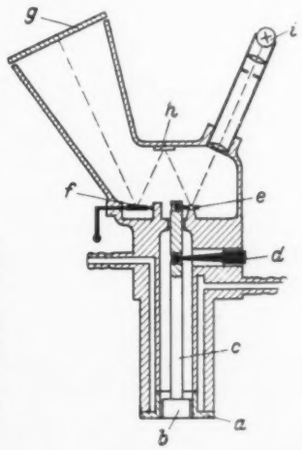

Fig. 84. The optical indicator of Von Gehlen (Maihak) is characterized by its compact arrangement. The piston *b* is arranged in a water cooled indicator cylinder, the size of which allows the indicator to be placed inside a spark plug hole. The piston is loaded by a cantilever spring *d* and its movements are transmitted to a rocking mirror *c*. The light ray, after passing the stationary mirror *h* is reflected again from the mirror *f* which is oscillated from the engine in unison with the engine piston.

the engine. Water cooling is provided for the parts exposed to heat. An electric pocket lamp serves as the source of light. The frequency of the moving parts is stated to be 1750/sec.

In comparing the merits and demerits of optical indicators, it can be said that diaphragms are liable to changeability of the pressure scale, hysteresis effect, deterioration due to fatigue and corrosion. (In some cases corrosion has been prevented by gilding the disks.) Spring loaded pistons have, on the other hand, larger mass and liability to lost motion, friction, leakage and seizure. Spring loaded diaphragms possess some good and bad points of both types. The mirrors must be mounted very carefully, otherwise backlash is likely to occur. Compared with other kinds of mirror-recording instruments, i. e. oscillographs, the optical indicators hitherto developed have a too long vibration period. A common drawback of all optical indicators is their relatively large bulk and weight. This makes it difficult to mount them close to the engine cylinder. Owing to this condition the indicator takes part in the vibrations of the engine. The resulting change of the position of the mirror relatively to the photographic plate is an undesirable error source.

---

[1]Descriptions of various optical indicators are contained in:
W. J. Stern & H. Moss. An improved model of optical indicator.
W. J. Stern & H. Moss. Notes on engine indicators.
F. Adcock. The indicating of petrol engines. *Proceedings of Institution of Mechanical Engineers.*

[2]Burstall. The Burstall Optical Indicator. *Engineering*, Jan. 26, 1932.

[3]Described in *The Engineer*, March 2, 1923, page 236.

[4]F. Nakanishi. *Journal Society of Mechanical Engineers.* (Japan) 1930, page 86. Reviewed by Johannes Kluge in *Forschung*, Feb. 1931.

[5]G. D. Boerlage and J. J. Broeze. The ignition quality of fuels in compression ignition engines. *Engineering*, Nov. 13, Dec. 4, & Dec. 18, 1931. The description presented here is based also on private information kindly supplied by Mr. Boerlage, in charge of the Proefstation "Delft."

[6]H. D. Brasch. Mechanische Spezialindikatoren. *Archiv fuer technisches Messen*, J-137-2, 1932.

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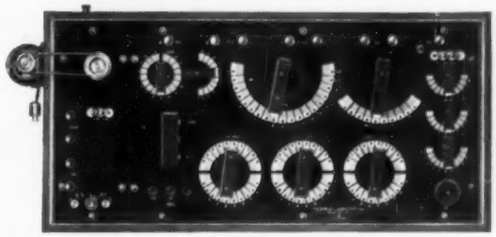

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INSTRUMENTS ABSTRACTS

Abstracts on instruments and devices for measurement, inspection and control.

ELECTRICITY AND MAGNETISM (4)

Electrical Measuring Devices and Applications (4.2)

Rectifiers Compared with Rotary Converters. C. M. Ward. *Power*, Vol. 75, April 5, 1932, pages 524-525.

Data are presented from operating records of 3 automatic mercury-arc and 2 automatic rotary converter substations of comparable size and operating under similar conditions for a 3-year period. There was practically no difference in operation and maintenance costs of the 2 types of converting equipment, taking into consideration the higher efficiency of rectifiers. Service availability of converters is slightly higher than that of rectifiers when the converting equipment is unattended and equipped with automatic control. Control system failures in whole or in part are vastly more serious in automatic than in manually controlled stations. More attention should be given to auxiliary relays, operating coils, protective equipment, etc., used in automatic control systems. AHE (4.2)

Investigations of the Time-Axis Release of a Cathode-Ray Oscillograph at Arbitrary Equalization Phenomena. (Untersuchung der Zeitkreisanslosung eines Kathodenstrahloszillograph bei unwillkurlichen Ausgleichvorgaengen.) K. Girod. *Archiv Elektrotechnik*, Vol. 25, Oct. 12, 1931, pages 695-704.

The performance of a time relay in connection with a cathode-ray oscillograph as developed by Rogowski is studied and a simplified connection described which reduces the back-action of the relay on the main circuit and increases the sensitivity. Ha (4.2)

Using a Watt-Hour Meter to Check Motor Loads. M. M. McIntire. *Power*, Vol. 75, Feb. 16, 1932, page 235.

Watts $= 3600\ NK/T$, where N is the number of revolutions made by the disk of a watt-hr. meter in T seconds and K is the disk constant. Values of K for various makes and types of watt-hr. meters are tabulated. If the meter installation includes current or potential transformers, K must be multiplied by the ratio of the transformer used. AHE (4.2)

Mercury Inverter. Ryotaro Mitsuda. *Transactions Tokyo Sectional Meeting, World Power Conference, 1929*, Vol. 3, 1931, pages 675-687.

A mercury inverter, a stationary d.c. voltage-transformer, and a stationary a.c. frequency-changer on an entirely new principle are described. The inversion from d.c. to a.c. on a commercial scale is attainable by cutting Hg arcs with revolving disks. Voltage-ampere performance and the wave form of inverted alternating voltage depend upon the amount of compensating condenser, which acts at the same time as an eliminator of anode flash. The efficiency of inversion has reached about 85% at d.c. 440 volts, 75% at d.c. 220 volts. AHE (4.2)

Measurement of Cutting Pressure on Tool Cutting Edges. (Schnittdruck-Messung au Werkzeugschneidern.) Geo. Keinath. *Archiv für Technisches Messen*, 1931, section V132-2, page T6.

In order to measure the three components of the cutting pressures of a tool during cutting, i.e., tangential, radial and axial, the condenser measuring box has been devised. Two plane-parallel steel disks in the box form an air condenser between the tool and the support. The tool pressure changes the air gap between the two steel disks, and, as the condenser forms part of a tuned oscillating circuit, disturbs the balance in the latter. The current is amplified and a record obtainable. Method and curves are illustrated; literature references are given. Ha (4.2)

Magnetic Properties, Materials, and their Applications (4.4)

Slow Motion Motor. Westinghouse Electric and Mfg. Co. *Instruments*, Vol. 5, May 1932, page 128.

Illustrated description of interesting new motor operating on principle of "vernier rotation." Stator produces magnetic field rotating 3,600 times per minute. It has 118 iron teeth on its inside edge. On outer edge of rotor are 120 iron teeth. Motor moves only the angle of 2 teeth for each revolution of the magnetic field. MFB (4.4)

Magnetostriction of Metals. J. S. Rankin. *Iron & Coal Trades Review*, Vol. 124, Mar. 18, 1932, page 472.

Tests are described for finding the effect of successive draws of wires on magnetostriction. The formerly assumed explanation of the decrease in magnetostriction with drawing seems not to be corroborated; at least, it cannot be attributed to inner stresses. An exact explanation cannot yet be given. Ha (4.4)

ELECTRONICS & RADIO (5)

Photo-electric Measurements, Devices & Applications (5.3)

Simplified Automatic Wilson Chamber. L. F. Curtis. *Bureau of Standards Journal of Research*, Vol. 8, May 1932, pages 579-582.

A description of a simplified form of exhaust or vacuum type Wilson cloud chamber, built for demonstrating ray tracks, is given. No vacuum pump or quick acting valve is required. By introducing some refinements this design seems adaptable also to the automatic photography of ray tracks. WAT (5.3)

Photo-Electric Developments in 1931. H. Olken. *Instruments*, Vol. 5, Jan. 1932, pages 1-4.

A bird's eye view of progress along photo-electric lines during 1931 is given. The review is divided into two parts; first, advances in photo-electric cells, then developments in applications of photo-cells to measurement and control. The notable developments of the year were not in photo-emission, but in photo-resistance and photo-voltaic cells. In the way of instrument applications a direct-reading illuminometer and a photo-electric recorder are treated. Under control applications are treated light-relays, control of temperature by measurement of radiation, and "code" control. HO (5.3)

Selenium Cells as Colorimeters. (Selenzellen als Kolorimeter.) Alex. Mickwitz. *Zeitschrift anorganische und allgemeine Chemie*, Vol. 196, Feb. 14, 1931, pages 113-119.

The paper reports some measurements of seleno-colorimetric absorption of light in colloid solutions of nickel sulfide and cobalt sulfide; the theory of the phenomenon is developed. Ha (5.3)

Some Photoelectric and Thermionic Properties of Rhodium. E. H. Dixon. *Physical Review*, Vol. 37, Jan. 1931, pages 60-69.

The photoelectric current of a thin strip of rhodium increases from 25 to 950° C by 130%, at 240° C a sudden increase took place. Another anomaly was found at 1100° C where the photoelectric current became irregular and the resistance temperature coefficient changed. Ha (5.3)

Photoelectric Relay for High-Speed Operation. General Electric Co. *Instruments*, Vol. 5, June 1932, page 161.

Description, photo, of new relay employing a photo-electric tube, an amplifying Pliotron and an operating Thyratron. MFB (5.3)

Photo-electric Tubes Used in Making Automobile Valves. F. L. Prentiss. *Iron Age*, Vol. 129, Feb. 11, 1932, pages 381-384.

The poppet valves are made by heading bar stock. Feeding of stock to electrically heated heading machine is controlled by photo-electric cell. When proper temperature is reached as indicated by color of stock, a photo-cell responsive to the color of the heated stock shuts off the electric heat and causes the header to operate. In hardening the stem tips electric heat is also used, also a photo-cell to shut off the heat when the color of the tip shows it has attained the desired temperature, and releases the valve into a quenching bath. HO (5.3)

Illumination Control. Weston Electrical Instrument Co. *Instruments*, Vol. 5, July 1932, page 182.

Brief description, 2 photos and 1 diagram, of new light-control device consisting of a light collector and a relay cabinet, latter containing all relays necessary to control a circuit of 3000 watts at 110 volts. MFB (5.3)

A Photo-electric Cell Circuit. G. A. Woonton & R. G. Elson. *Canadian Journal of Research*, Vol. 6, Apr. 1932, pages 444-451.

Describes a stable vacuum tube circuit capable of linear response to the varying conductivity of a photo-cell, and a method is suggested whereby light intensities of widely different magnitudes can be compared. OWE (5.3)

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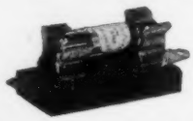

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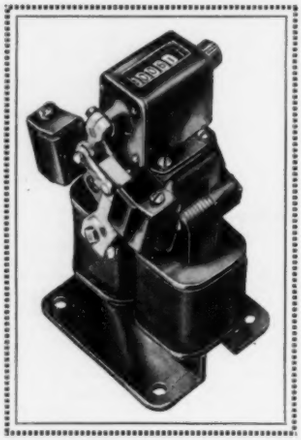

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TREND-ANALYZING CONTROL

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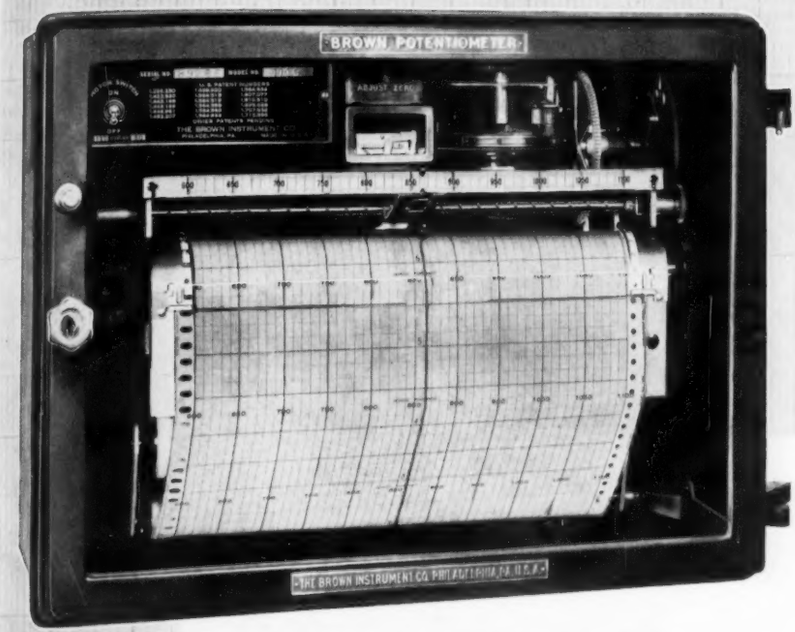

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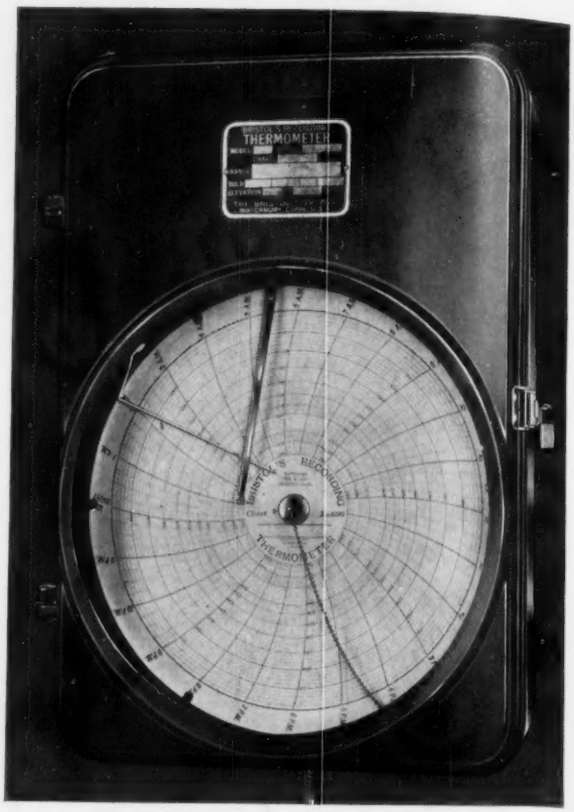

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WHERE BRISTOL'S RECORDING THERMOMETERS ARE USED

INDUSTRY / PROCESS	Chemical Reaction	Evaporation and Distillation	Heat Transfer	Drying	Process Steam Generating
Ceramics			X	X	X
Chemicals	X	X	X	X	X
Coke		X	X	X	X
Drugs, Cosmetics	X	X	X	X	X
Explosives	X		X	X	X
Fertilizers	X			X	X
Glass				X	
Glue, Adhesives		X	X	X	X
Leather	X			X	X
Lime, Cement				X	
Manufactured Gas				X	X
Oils, Greases	X			X	X
Paints, Varnish					X
Paper, Pulp	X	X			X
Petroleum Refining	X	X	X		
Rayon	X	X	X	X	X
Rubber	X			X	X
Soap	X	X	X	X	X
Sugar	X	X	X	X	X
Other Industries	X	X	X	X	X